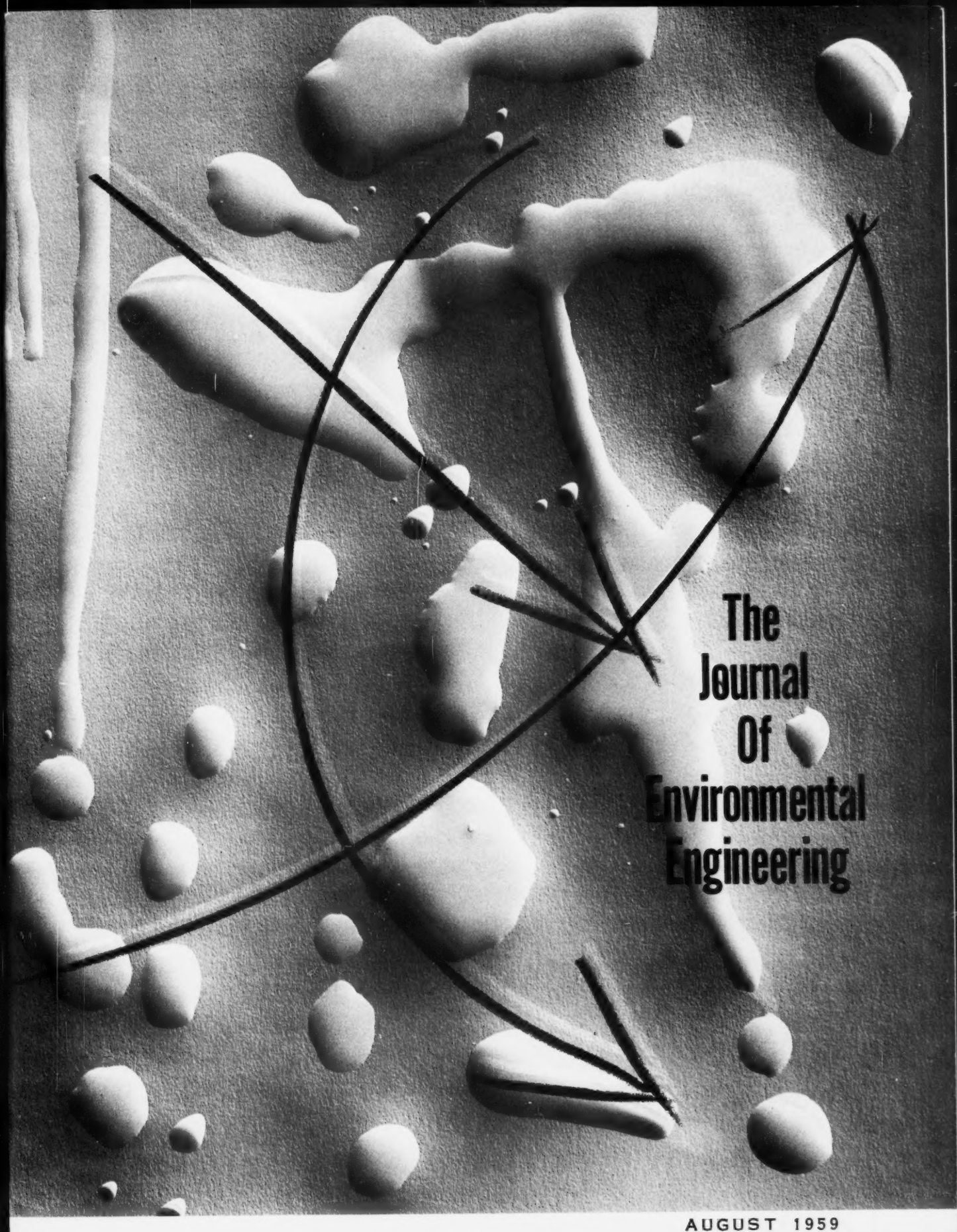

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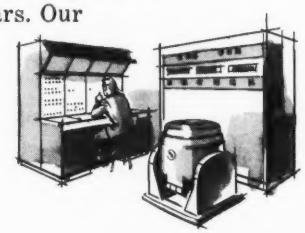

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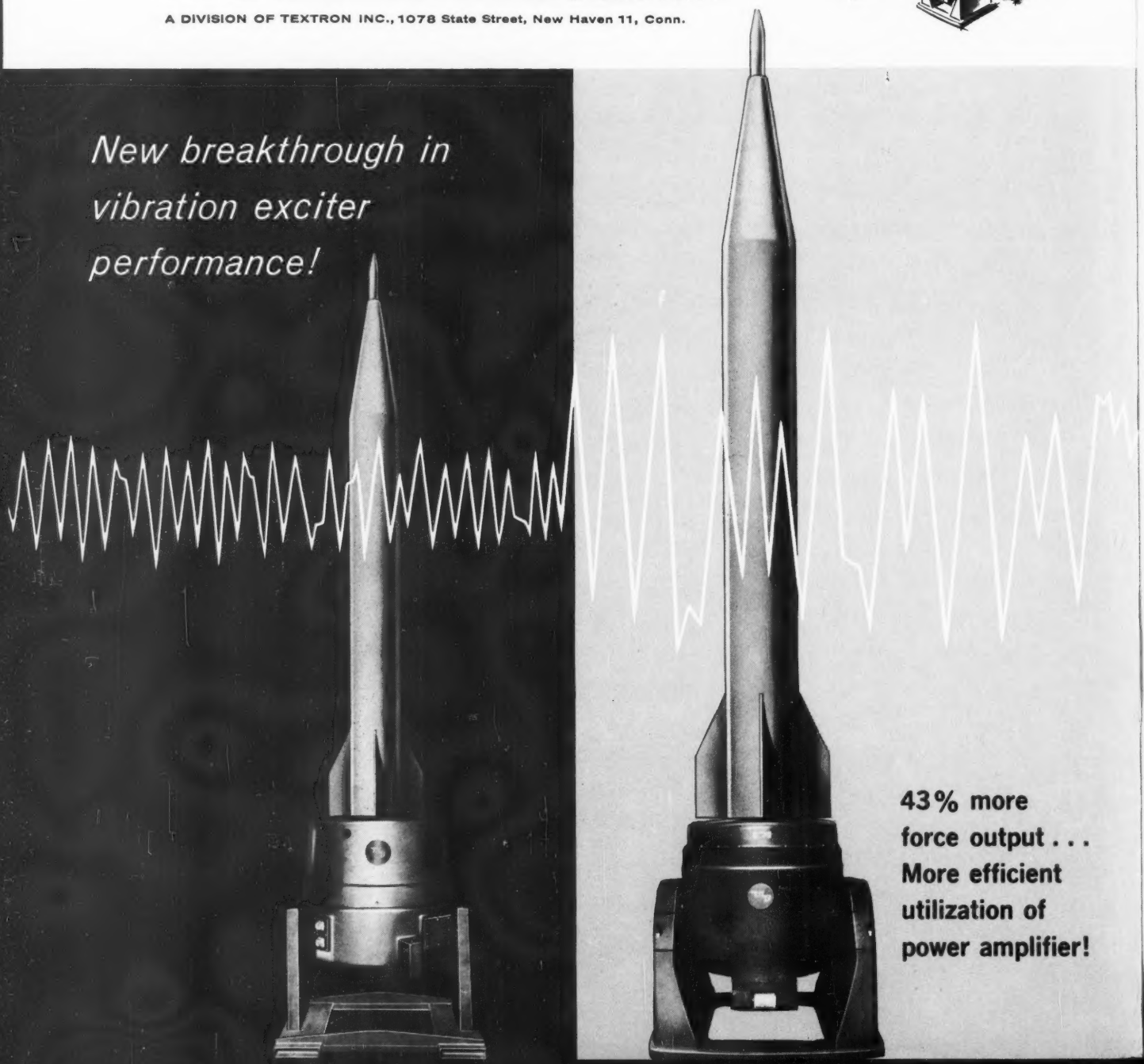

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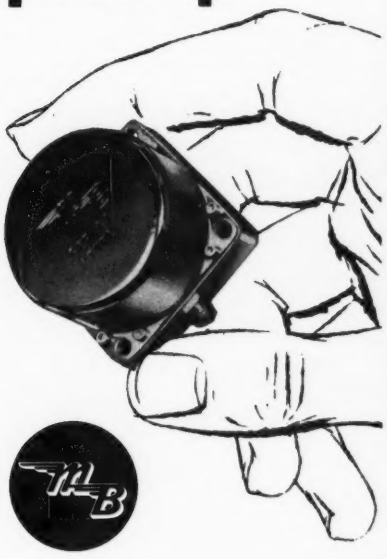

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VOLUME 2 NUMBER 4

Published for active Environmental Engineers and the executives throughout industry who are concerned with the advancement of Environmental Engineering by the Institute of Environmental Sciences.

Charles W. Danielson, Technical Editor **AUGUST 1959**

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DESIGN OF AN IMPROVED OPTICAL SYSTEM for High Frequency ACCELEROMETER CALIBRATION

L. E. HAYES
RESEARCH ENGINEER
ENVIRONMENTAL LABORATORY
AUTONETICS
DIVISION OF NORTH AMERICAN AVIATION INC.

FIRST OF TWO PARTS

INTRODUCTION

During the past thirty years, shock and vibration phenomena have received considerable attention in the study of structural stresses and in the protection of equipment against damage during transportation and field use. Until approximately ten years ago, vibration tests were limited to the frequency range between 5 and 500 cps and to low acceleration levels. Because of test requirements introduced with the development of jet aircraft and missiles, higher acceleration levels and an expanded frequency range from 5 to 2000 cps are now generally employed. In the near future, test requirements are expected to include vibration tests at frequencies above 10,000 cps.

Paralleling the demand for vibration testing at higher frequencies has been the development of the necessary vibration test equipment for use in these extended frequency ranges by various equipment manufacturers. Included in the test equipment presently employed by many test laboratories are electromechanical vibrators and vibration transducers of various types.

Since the quantity of vibration or the acceleration level employed in vibration tests is controlled by noting the response to vibratory motion of some type of transducer, it is imperative that the transducer response characteristics be accurately known. One of the most important of the transducer characteristics is its frequency response. During the past ten years several calibration systems have been placed in service for determining accelerometer frequency response.

Most of these systems employ some device for accurate measurement of the accelerometer displacement amplitude as well as providing a means to measure the electrical output and excitation frequency of the accelerometer. With the displacement and excitation frequency known, the acceleration levels can be computed from:

1. $A = 0.05115\ DF^2$

where A is the acceleration level

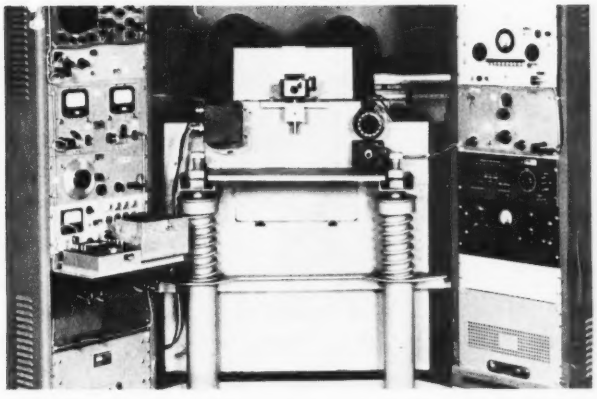

Figure 1. General view of calibrator system

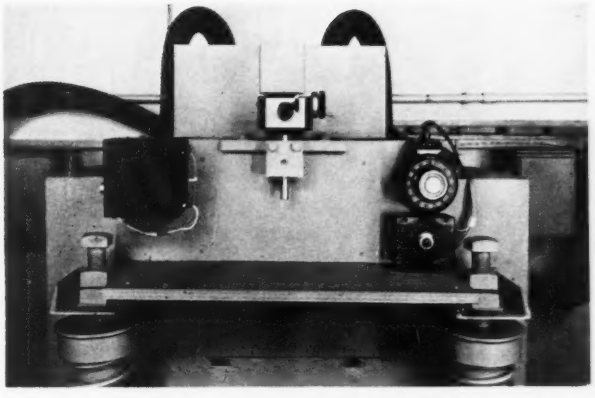

Figure 2. View showing part of calibrator ventilation system

in gravitational acceleration units; D is the accelerometer peak to peak displacement in inches; and F is the excitation frequency in cps. Finally, the accelerometer sensitivity, S, expressed in millivolts per g can be computed by:

$$2.\quad S = \frac{E}{A}$$

where E is the accelerometer output in millivolts and A is the acceleration level computed from equation 1. Computations based on equation 1 show that D becomes less than 0.001 inch when F is greater than 500 cps for acceleration levels less than approximately 15 g. Thus, because of the extremely small displacement amplitudes encountered at excitation frequencies above 500 cps, a high frequency calibration system must accurately measure very small motions. All of the calibration systems presently employed have limited frequency response. Some systems are best suited for calibration at frequencies below 500 cps while others are best suited for measurements above 2000 cps. None of these calibration systems are well adapted to the range between 500 cps and 2000 cps.

A common system often used for accelerometer calibration employs a micrometer microscope for measuring accelerometer displacement amplitudes. To indicate motion, light is usually reflected from a fine horizontal wire cemented to the vibration table. In such an arrangement, the wire appears as a tiny line of light which becomes a wide band in the microscope field when the vibration table is excited. The width of the band becomes the apparent displacement amplitude and is accurately measured by comparing with a graduated scale mounted in the microscope reticle or by noting on the scale of a slide micrometer the change in the position of a set of crosshairs as the hairs are adjusted across the width of the band. The true displacement amplitude is computed by subtracting the original wire diameter from the measured width of the band.

The micrometer microscope system noted above is normally limited to low frequency measurements because of the limited resolution of commercially available slide micrometers and microscope. With these instruments, to achieve amplitude displacement measurements with one percent error, the displacement amplitude must be at least 0.001 inch. Such displacement amplitudes occur only at frequencies below 500 cps unless high excitation levels are employed. Also, since most calibration systems employ electromechanical vibrators, the 60 cps supply line interference and transients normally encountered with such vibrators, prevent accurate cross hair adjustments. Because of these limitations the micrometer microscope technique for measuring displacement amplitudes is normally limited to excitation frequencies below 150 cps. The following report describes a calibration system employing a

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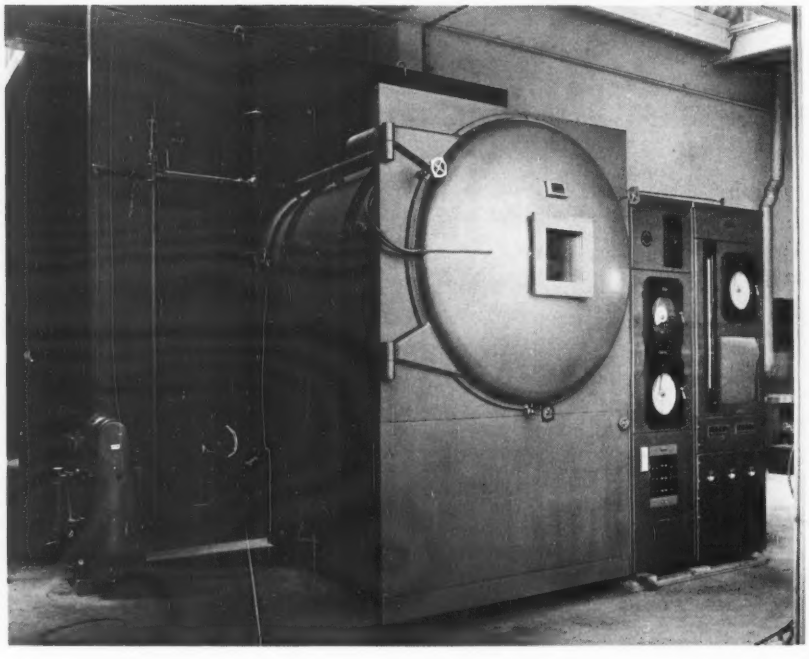

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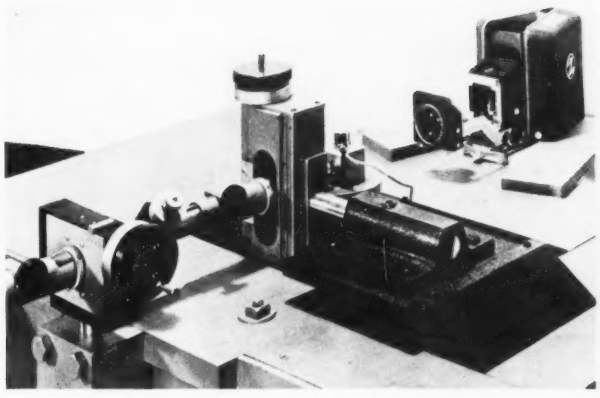

Figure 3. View micrometer microscope and light system

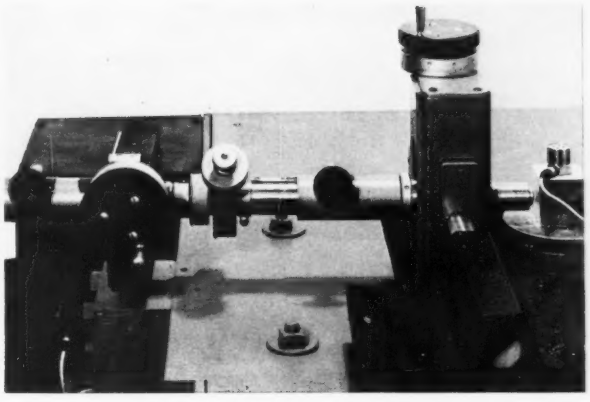

Figure 4. View-showing-bifiler micrometer and aluminum cube accelerometer mount

modified micrometer microscope recently placed in operation by the writer to determine accelerometer frequency response for excitation frequencies below 3000 cps.

DESIGN OF AN IMPROVED MICROMETER MICROSCOPE CALIBRATION SYSTEM

The micrometer microscope technique for measuring displacement amplitudes could be used at excitation frequencies considerably above 150 cps if the microscope and vibrator limitations were removed. Recently the author placed into service a system which is presently used to accurately measure accelerometer displacement amplitudes at frequencies ranging from 100 cps to above 2000 cps. The calibration system consists of the following pieces of equipment.

1. An electromechanical vibrator and power supply with a specially designed mechanical damper and cooling system.
2. A specially designed compound micrometer microscope.
3. A specially designed optical slit system and light source.
4. An accurate voltage standard, distortion analyzer, and electronic counter for accurate measurements of accelerometer cathode follower voltage output and excitation frequency.

Each of these pieces of equipment is described in the following paragraphs.

THE ELECTROMECHANICAL VIBRATOR, DAMPER, AND COOLING SYSTEM

When the accelerometer calibration system was first planned, an MB C-11-C Electromechanical Vibrator with its Model P11-D Amplifier and Model F31C Field Supply were chosen for the system. The vibrator is mounted on a large seismic mass of steel reinforced concrete which is supported by large compression springs. This arrangement removes most of the vibration transmitted through the floor. The concrete block and its suspension are shown in Figures 1 and 2.

As was previously noted, almost all electromechanical vibrators suffer from various amounts of 60 cps excitation from their power supplies and transient motions which are extremely difficult to remove. After various electronic filter systems proved inadequate, a mechanical damper, composed of a spring system mounted between the vibrator table and frame, was constructed. Exceptional success has been achieved with this arrangement which is now in service.

When initial testing of the calibration system began, the test results indicated that accurate temperature control of the

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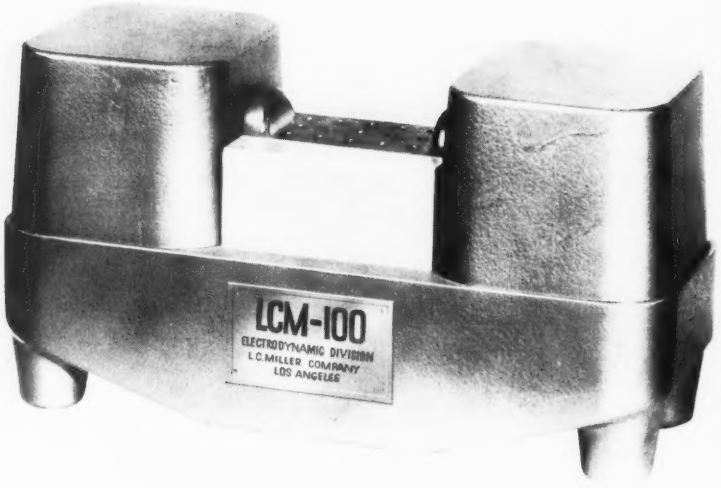

The LCM 100* is a new type of vibration exciter which features a horizontal, air supported, push-pull driven table. Although primarily designed for the *production testing* of components and small subassemblies, the unit's wide frequency range (5 to 15,000 CPS) and high force output will make it an ideal *research tool* for the product design engineer. The ruggedly built instrument is simple to operate, thus avoiding possible damage by inexperienced personnel.

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The shaker table is supported by *air bearings* which stiffly confine movement of the table in all directions but the axis of excitation. This new air suspension system eliminates troublesome springs and flexures; and reduces *cross talk*, a major problem with many shaker systems, to an exceptionally low value.

"Heavy" specimens are easily handled as the weight of the table and specimen is supported by air pressure normal to axis of excitation.

MORE EFFICIENT

Due to the low friction of the air bearings and the push-pull drive, the electrical efficiency of the shaker table is very high (2 watts per force pound as compared with 10 or more watts per force pound needed by conventional systems.) This enables efficient use of standard audio amplifiers which permits a substantial cost reduction over other vibration exciters using special high-power, limited-frequency amplifiers. Permanent magnets are used in the LCM 100 magnetic circuit to eliminate the need for separate field excitation and associated rectifying equipment. The impedance of the drive coils is designed to match the power amplifier over the entire audio range.

MORE ACCURATE

The LCM 100 is suitable for use with all forms of excitation including: discrete frequency, random noise, white noise, or complex wave form.

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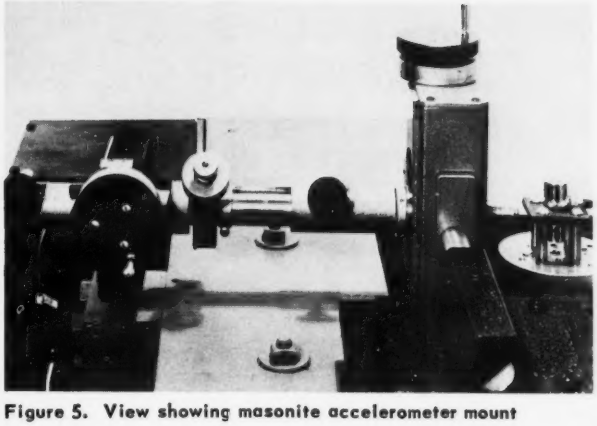

Figure 5. View showing masonite accelerometer mount

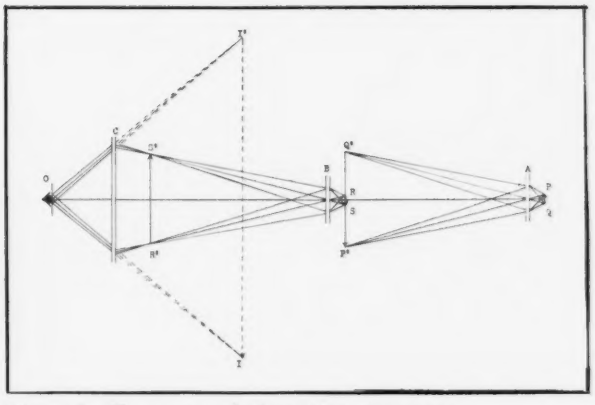

Figure 6. The compound micrometer microscope

slit fixture and the vibration table was essential. The necessary temperature control was achieved by enclosing the vibrator and a portion of the optical system in a wooden enclosure and by employing a closed ventilation system. In this arrangement, the air warmed by the heat generated in the vibrator is pulled from the bottom of the enclosure by two exhaust fans. After passing through the fans, the air is cooled by passage over perpetually wet surfaces located within two wooden enclosures. The cool air is then recirculated back into the top of the vibrator enclosure. Portions of the cooling system are shown in Figure 2.

THE COMPOUND MICROMETER MICROSCOPE

The standard micrometer microscope was found completely inadequate for measuring accelerometer displacements with amplitudes less than 0.001 inch if errors were to be maintained less than two percent. These microscopes have three limitations. First, the maximum magnification is not sufficient to produce the necessary detail in the slit excursion image. Second, the hair line images are too small and can not be seen well enough to accurately adjust them on the slit excursion limits. Finally, because the best available slide micrometers have scale divisions of 0.001 mm and can be read to approximately 0.0001 mm, these instruments do not have the necessary resolution to permit accurate measurement of the cross hair position. Thus, the improved micrometer microscope required larger magnification of slit and cross hairs as well as a more accurate means to read the cross hair position.

The final version of the improved microscope, shown in Figures 3, 4, and 5, consists of a primary and secondary objective lens systems, a set of cross hairs attached to a bifilar screw micrometer, two slide micrometers, and an occular. Referring to the ray diagram in Figure 6, it is noted that light rays from the object (the optical slit), PQ, pass through the primary objective lens system A and form an enlarged, inverted, real image at P'Q' in the focal plane of lens system A. A small portion of this real image is taken as a new object RS and the rays from this object pass through the secondary objective B after which they form another enlarged, erect, real image R'S' in the focal plane of lens system B. This real image is again magnified by the occular C to form the virtual inverted image II' seen by the observer O. By using standard, commercially available lens system for A, B, and C, magnifications as large as 8,000 can be employed. The system presently employed uses magnifications between 2000 and 4000.

The hair lines mounted in the bifilar screw micrometer, are located in the focal plane of lens system A as is the image P'Q' and thus they are magnified by lens systems B and C. By this magnification, the hair lines become much more distinct and thus, the task of positioning them on the slit excursion limits is

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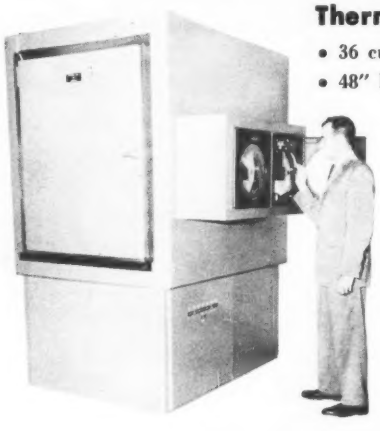

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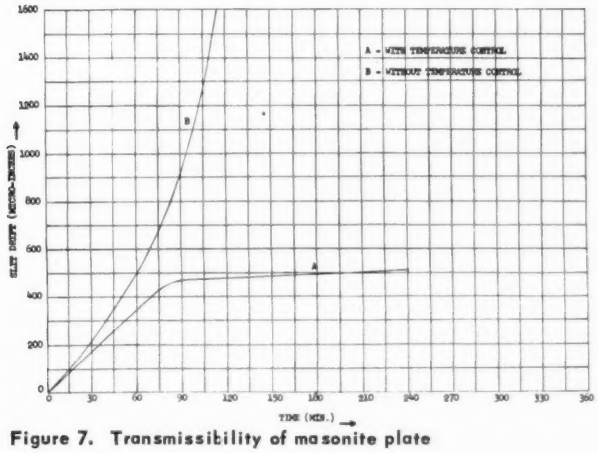

Figure 7. Transmissibility of masonite plate

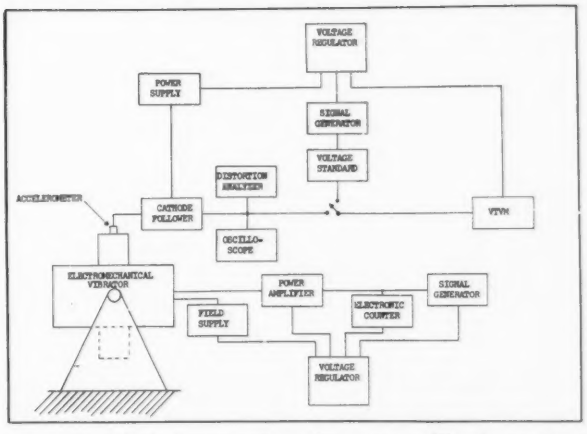

Figure 8. Block diagram of accelerometer calibration system

much simplified. Also, because the thread of the screw micrometer in the bifilar instrument has a much finer pitch than those of the slide micrometers, the hairline motion is more easily controlled. The two slide micrometers are used merely to align the optics in the vertical and horizontal planes. To focus the instrument, the objective A is first focused on the slit. Then objective B is focused on the image P'Q' and the hair lines. Finally, the eyepiece or occular is focused. This procedure is repeated to achieve fine focusing.

THE OPTICAL SLIT SYSTEM AND LIGHT SOURCE

Originally, an 0.0003 inch illuminated slit formed by the controlled separation of two milled steel blocks was used to indicate the vibrator displacement amplitudes larger than 0.001 inch. To facilitate displacement amplitude measurements in the microinch ranges a new slit was formed by scribing a line 0.000035 inch wide in a thin aluminum film deposited on one surface of a small glass disk. By using an optical wax, the glass disk was cemented into a cell formed in one surface of a 1-1/4 inch aluminum cube. To expose the slit to the light beam from the incandescent light source, a hole was drilled through the cube behind the cell holding the glass disk. An amber filter was placed in the cube surface opposite the slit cell. The slit fixture and light source can be seen in Figure 4.

ACCELEROMETER MOUNTS

When employing the optical system described above in accelerometer calibrations, the accelerometer is mounted on the upper surface of the aluminum cube containing the optical slit. Because such calibrations are necessarily a lengthy process requiring approximately two hours for a single accelerometer, this system is best suited for calibrating accelerometers to be used for laboratory standards.

For routine calibrations where time is an important factor, the output of the accelerometer being tested is compared with that of the standard accelerometer. To achieve this comparison, the accelerometers were mounted in various ways including direct mounting to the vibration table as well as being mounted back to back in various metal and non metal fixtures.

The best mount developed to date is shown in Figure 5 and consists of a masonite plate 1-1/2 inches square and 1/8 inch thick supported by four machined brass spacers 1 inch long. As shown in the photograph, the two accelerometers are mounted back to back with the masonite plate between them. A plot of transmissibility vs frequency for the mount is shown in Figure 7.

ACCELEROMETER OUTPUT MEASUREMENTS

The output of the accelerometer being calibrated is normally expressed in terms of the voltage developed at the open end of a given length of an ap-

Continued on page 29

ALTITUDE AND VACUUM CHAMBERS

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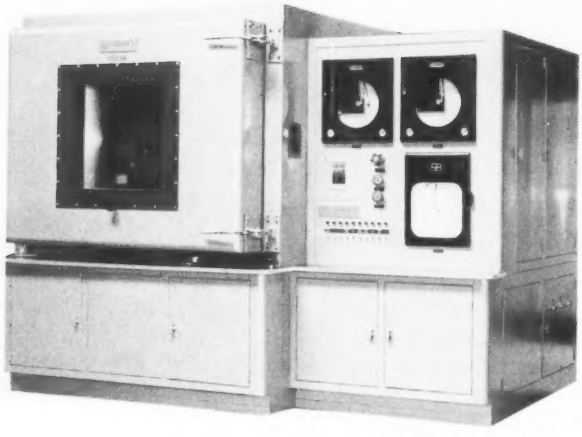

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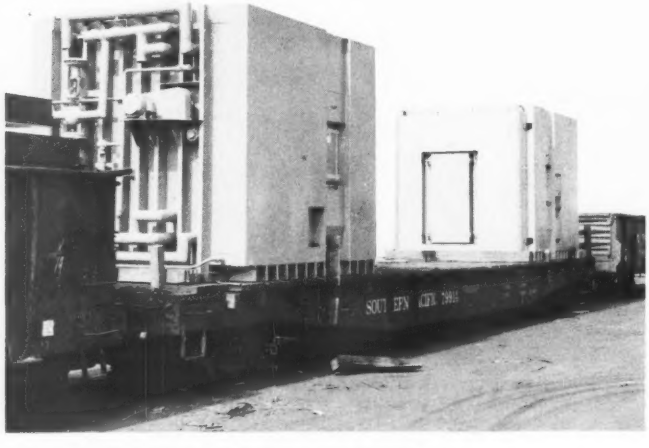

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Doc. #IES-60 N M 1 A -- Meeting Outline

MEETING OBJECTIVE

The goal of this meeting is to step-up advanced rocket and space systems timetables through an intensive three-day interchange in the environment technology.

MEETING OUTLINE

The Meeting will offer two programs daily (morning and afternoon). Each program will be comprised of three parallel sessions, each devoted to a principal subdivision of research and development:

1. Space systems and hardware
2. Space systems and human factors
3. Terrestrial support (ground and air)

Each day, one of three major problems will be treated:

A. First day - Defining environments
B. Second day - Designing for environments
C. Third day - Proof testing

SUBJECTS

a. Thermal extremes
b. Zero gravity
c. Space vacuum
d. Dissociated gases and ionization
e. Meteoric particles
f. Radiation--Cosmic, solar, nuclear, electromagnetic
g. Induced stresses--Shock, vibration, acceleration, and sound
h. Environments in combination
i. Sequential environments (trajectory)
j. Planet and satellite environments
k. Reliability and the environments
l. Transportation and handling environments
m. Storage environments

PAPERS

Authors planning the treatment of their material may find the following questions helpful. These questions should be considered as being suggestive of the program coverage desired, but not all-inclusive. Any paper which falls under one of the three major program subdivisions and deals with one of the three problem topics may be presented for consideration.

First Day Defining Environments

What are hyper-environments? ordinary terrestrial environments? How are they measured? How can values for these environments be predicted? How can design requirements be specified? What are some effects produced by these environments? How are reliability predictions adjusted for the environmental factors? What influence will combinations of environments have? What new systems design problems are anticipated? What programs are recommended to extend our knowledge in the environment science?

Second Day Designing for Environments

What has been done to increase resistance against degradation caused by environments? What new developments give promise of advancing designs for severe environments? How can general design principles or specific rules be applied to achieve greater reliability in extreme environments? What major limitations in existing subsystems are associated with the environmental problem? What improvement methods should be pursued in specific sub-system areas--evolution or revolution in design approach?

Third Day Proof Testing

To what extent can laboratory testing prove a design? How good is Production Environmental Testing for quality control? What peculiar modes of failure are obtained only with combined environmental testing? What special tests are recommended to replace or augment conventional environmental tests? What are some new facilities that are available? What unique solution to a testing problem have you discovered? How can testing be better controlled or otherwise improved?

Doc. #IES - 60 N M 2 A -- Administrative Policies

PURPOSE

The purpose of this document is to set down policies which will be administered by the Institute of Environmental Sciences in organizing the technical sessions of its 1960 National Meeting. These policies are being adopted in an effort to obtain a high quality of technical interchange.

PROCEDURE

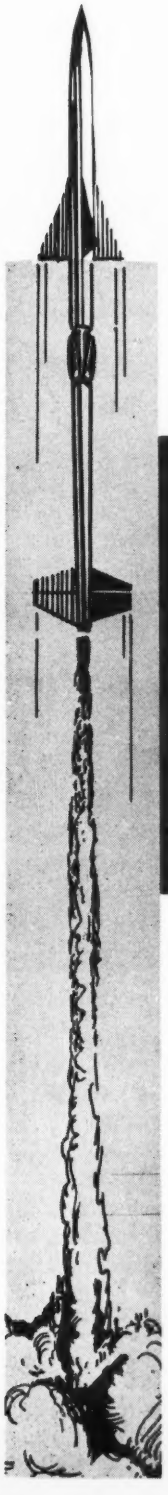
Technical papers will be solicited from industry, government and university scientists and engineers who have made significant contributions to the environment technology in the past. To assure that papers will be compatible with the meeting objectives, they will be screened using the following criteria:

a. Does the paper fit the outline of DOC # IES-60NMIa?
b. What is its significance

continued on page 23

flight testing on the ground

Environmental and Performance Testing for Quality Control, Reliability, and Qualification of Electrical, Electronic and Electro-Mechanical Components, Sub-Assemblies and Assemblies



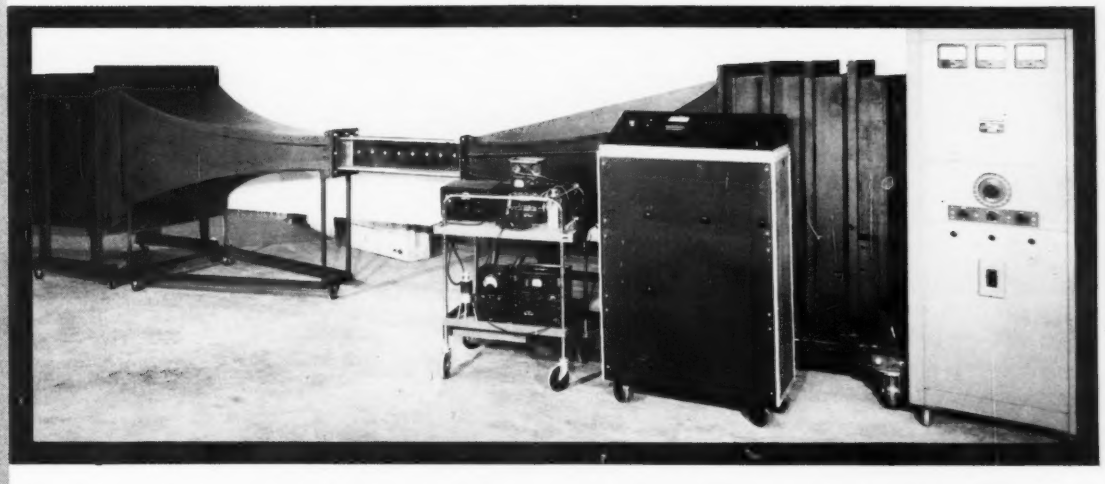
RANDOM NOISE ACOUSTICAL TESTING

Frequency spectrum: 75 cps to 10 K cps

Sound pressure level:

153 db (re: .0002 dynes/cm^2) in test chamber 5" x 5" x 16"
150 db in test chamber 8" x 8" x 40"
135 db in test chamber 40" x 40" x 40"

INTERMEDIATE SOUND PRESSURE LEVELS AND CHAMBER SIZES ALSO AVAILABLE



Acoustical vibration has recently been found--by the major airframe and missile manufacturers--to be an environment of prime importance in structures and electronic gear associated with jet and rocket engines. Rototest has developed and has operational a complete facility for testing components in high intensity sound vibration; much exceptional behavior has already been found in parts subjected to this environment.

Rototest is accepting requests for proposals to supply complete Acoustic Vibration test facilities.

ANOTHER ROTOTEST FIRST

CINE-RADIOGRAPHY: *Dynamic application of X-ray motion pictures to the study of behavior of electrical, electronic, electro-mechanical, hydraulic components, assemblies and sub-assemblies while under such environmental stresses as vibration and shock.*

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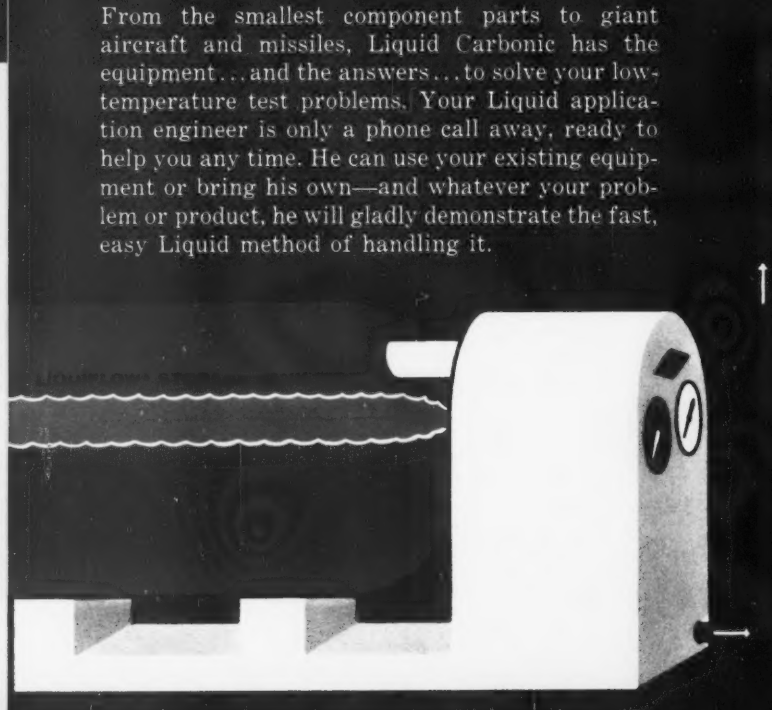

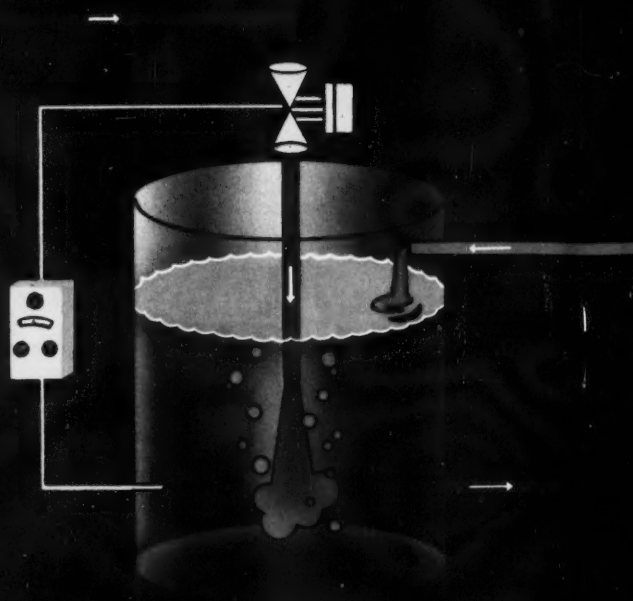

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Ideal for fuel, vacuum, hydraulic fluid or altitude testing. This unique indirect system can be adapted to existing overloaded mechanical systems, and is suitable for cooling jet engine fuels or for such human factor testing as space suits. Here's the fast, easy way to make environmental low-temperature tests—resulting in better, more dependable products. For top performance wherever normal atmospheres must be maintained, Liquid's indirect solvent system is the answer.

MULTIPLY YOUR ENGINEERING MANPOWER!

If your mechanical refrigeration unit is taking 8-10 hours to pull down from 200° F. to —65° F., CO_2 will do the same job in 8-10 minutes! Liquid's direct CO_2 injection pulldown to mechanical hold actually increases productive engineering time. Here is the ideal unit for your "fast-drop" tests to save both time and money.

Ask your Liquid Carbonic application engineer how *you* can save with a fast, improvised test on *your* product! Contact him today for a demonstration with this portable CO_2 testing equipment right in your own plant or laboratory at no obligation.

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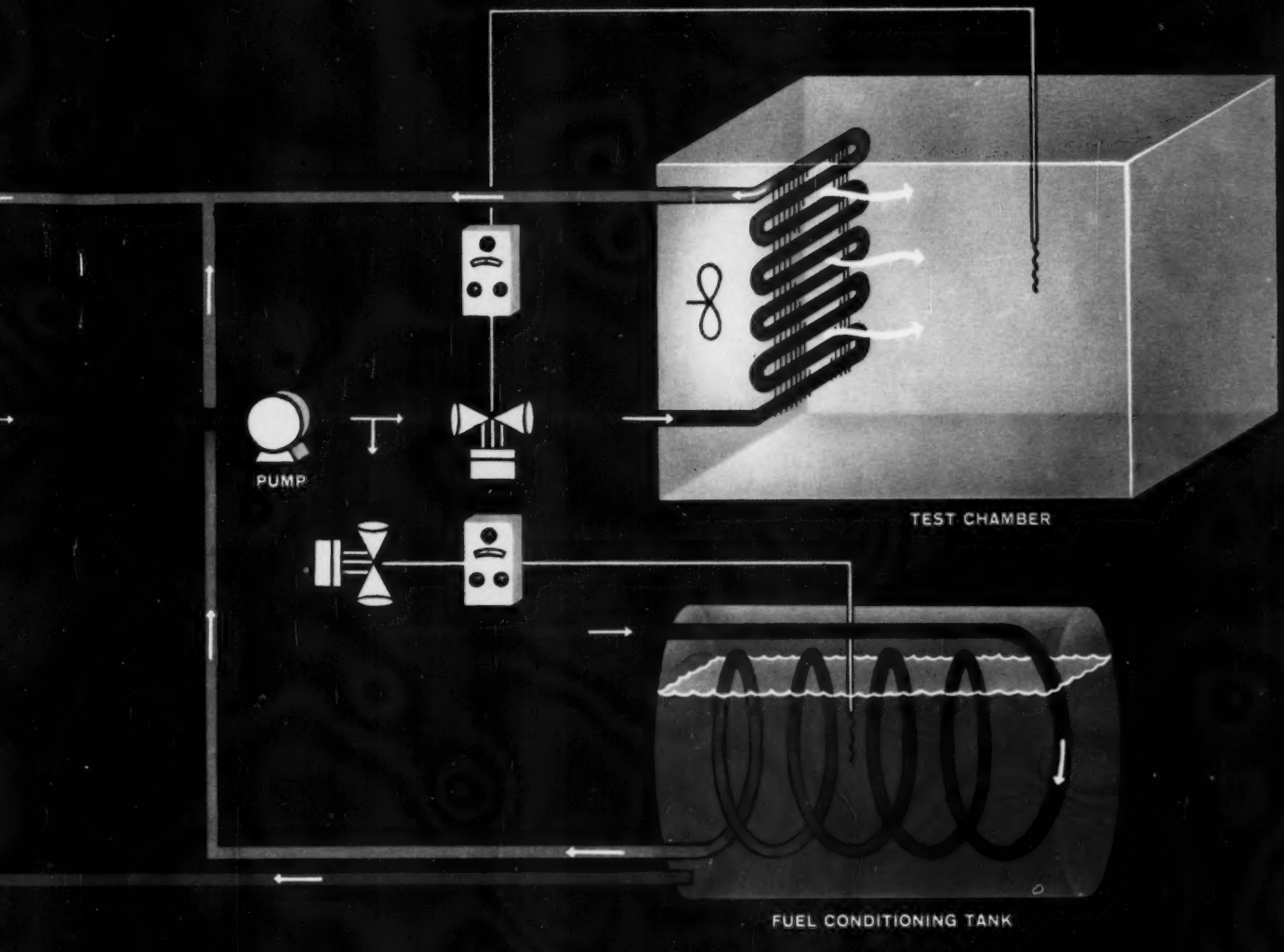
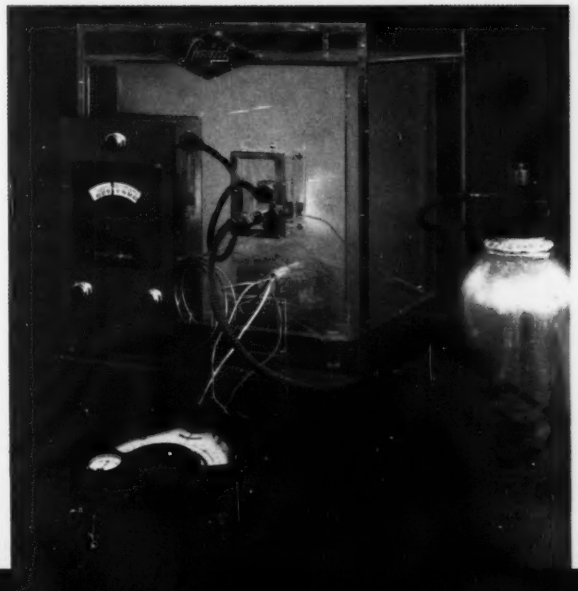
environmental testing with CO_2



DIRECT INJECTION

You can have unlimited refrigeration capacity with only a temperature controller and valve, chamber, and low-cost CO_2. In fact, for one ton of refrigeration per hour, you need only approximately one pound of CO_2 per minute! This handy unit is inexpensive and easy to operate, gives immediate pulldown to −109° F., and lends itself to simple automation.



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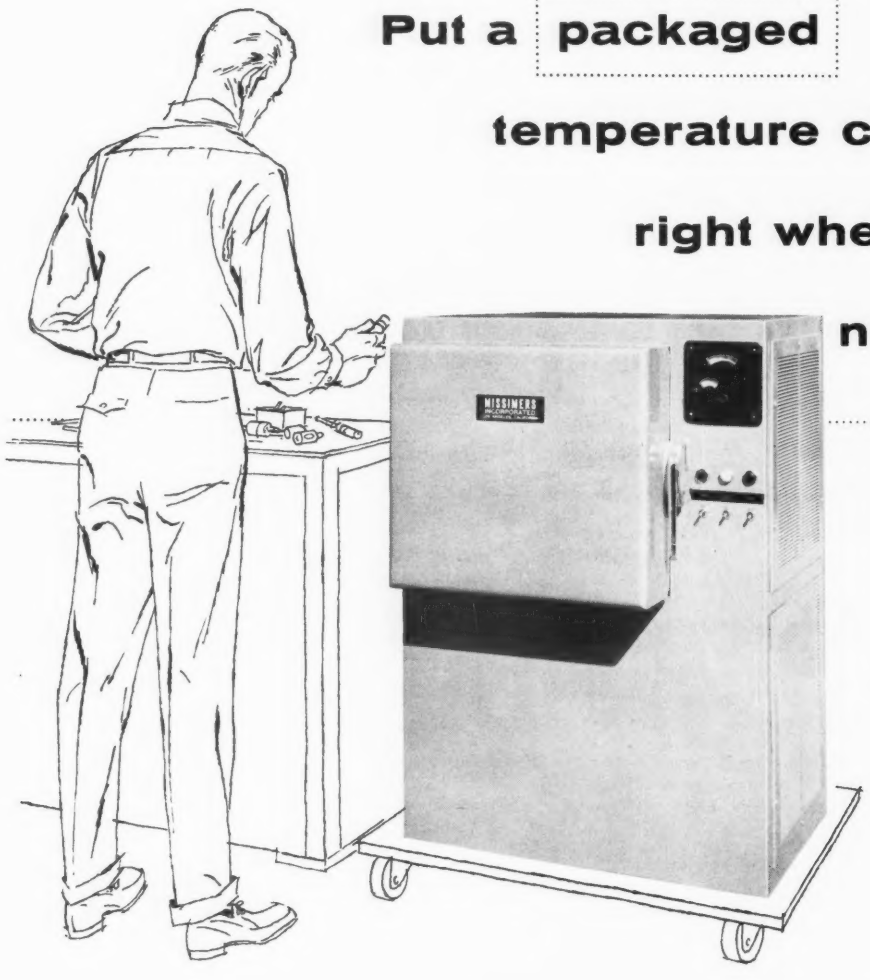

THIS ECONOMICAL MISSIMERS CHAMBER MEETS MIL-SPEC ACCURACIES WITH PLUG-IN SIMPLICITY

Quickly set up almost anywhere, this new unit is designed to fill the need in many testing laboratories and company facilities for an accurate, yet economical temperature chamber. It can handle overflow work from larger chambers, run qualification and reliability tests on small products or components, and is ideal for production processing and temperature stabilization work.

A hermetically-sealed cascade refrigeration system provides temperatures to −100°F, and a special heating unit to 350°F. Temperatures are controlled to ±3°F over the full range.

The one cubic foot working space has a full opening door. Forced air circulation provides uniform temperatures within the chamber.

As a standard model, this chamber is priced to be practical for almost anyone... will test to Mil-Specs... and is guaranteed for a full year.

Write for specifications and prices on Model FT1-100x350, or for information on any of Missimers full line of environmental chambers.

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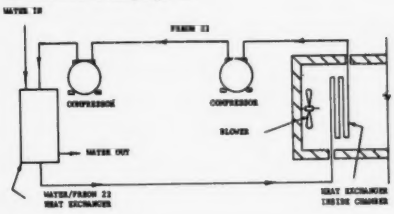
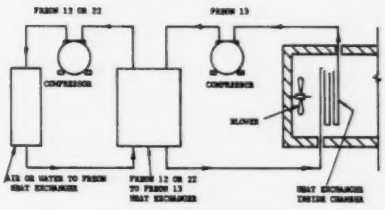
Western Sales Representative: Pacific Scientific Company

continued from page 13



Typical "Compound" System
(Simplified)



Typical "Cascade" System
(Simplified)

before another low temperature test is started.

There are a number of good insulating materials, such as aerated silica gel, fiber glass, foam glass, and loose fill types such as "Zonalite". All are adequate over normal test ranges (–150 °F to +450 °F), with foam glass blocks being used for temperatures used to 1000 °F. Occasionally a combination of these insulations is used on special purpose chambers.

COOLING SYSTEMS

The cooling system is the heart of any climatic chamber by injection of CO_2 or sublimation of cakes of dry ice. The first, "liquid CO_2" is quite effective, and lends itself to multiple chamber installations or large chambers quite well, particularly where sporadic use is the rule. This arrangement is considerably cheaper in operation than a dry ice system, since no CO_2 is used except when cooling is called for, as opposed to the continuous loss of dry ice whether in a chamber or in storage. Another very satisfactory arrangement is the CO_2 cooling of a "brine", usually methyl alcohol, which is then circulated through heat exchangers in the chamber or chambers upon demand of the temperature controller. Due to the recent large production of liquid oxygen, liquid nitrogen has become readily available at a reasonable cost and serves as another expendable refrigerant. Its use may be compared with liquid CO_2 with further advantages of lower temperatures (–300 °F and below) and lack of a tendency to turn to "snow" as does liquid CO_2 when expanded directly.

Most chambers today are supplied with an integral mechanical refrigeration system using one or more of the "Freons" as refrigerant. These systems are usually either of the "compound" (see sketch), or "cascade" type. In general, cascade systems are almost universally used in smaller chambers (up to 60" x 60" x 60"), with both types used on larger chambers according to use. As the sketch shows, a compound system usually uses Freon 22 with two or more stages of compressors, while the cascade

Continued on page 26

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continued from page 18

relative to national needs?

c. Does the paper present advanced information?

d. Does it remain primarily within the scope agreed upon by the IES and the author?

The IES will print each accepted paper. These will be available at the National Meeting in either single or quantity lots for a nominal charge. In addition, a complete collection of papers will be available for purchase in a bound volume entitled "Proceedings of the Fourth National Meeting, Institute of Environmental Sciences." At the discretion of the IES, papers which are considered acceptable may be printed in the Proceedings, although they were not included in the technical sessions. Authors will be notified as to the makeup of the program and the Proceedings on or before March 11, 1960.

To permit sufficient time for selecting, editing and printing of the papers, the IES regretfully must establish and maintain deadlines for certain stages of the work. These have been set as follows:

ABSTRACT (Preliminary)..... With letter of reply by author accepting invitation

SUMMARY (About 200 words) .....October 14, 1959

continued on page 32

Introducing The I. E. S. New Executive Board

HAROLD C. JONES
President

Born and raised in the southwest, graduated BSEE Illinois Institute of Technology, 1949. Spent nine years with Westinghouse Electric and one year with Hughes Aircraft. Last five years of time with Westinghouse was in Environmental field. Position with Westinghouse at time of leaving (September 1958) was that of Project Engineer in Environmental section. Presently an instructor in the Electrical Engineering Department at the University of Maryland and consultant in Reliability and Environmental for Maryland Division, Litton Industries. ■■■

WILLIAM L. VANDAL
Executive Vice President

William L. Vandal is Engineering Group leader of the Environmental Laboratory at Autonetics, a division of North American Aviation, Inc.

Vandal joined North American in 1950 and has headed the environmental testing facility at Autonetics since the division was formed in 1955.

He is a recognized authority in Dynamics (vibration, shock and acceleration testing) and Atmospherics (simulation of altitude, temperature, sand, dust, salt spray, fungus and humidity environments).

Vandal graduated from New York State Teachers College in 1941. From that time until 1944 he was a member of the USAF Technical Training Command when he enlisted in the U. S. Navy as an electronics technician.

Following his release he worked as a research engineer in electronics at Engineering Research Associates until joining North American.

Vandal was a charter of both the Institute of Environmental Engineers and the Society of Environmental Engineers - both organizations now merged into the Institute of Environmental Sciences of which he is executive vice president. He is also an associate member of Institute of Radio Engineers and has presented a number of papers before specialized groups dealing with environmental testing.

He is a lieutenant in the Naval Reserve, an avid sports car fan, and lives with his wife and three children in Garden Grove, Calif. ■■■

ARTHUR B. BILLET
Vice President - Fiscal Affairs

Senior Staff Engineer, Aero Hydraulics Division, Vickers Incorporated for the past 3-1/2 years.

Laboratory Supervisor of Aero Hydraulics work, Vickers Incorporated - 12 years.

Pilot and flight instructor USAF - 1942 - 1943.

Aeronautical Engineering -- University of Michigan.

National Vice President of the Institute of Environmental Sciences since 1957.

President of Detroit Chapter of Institute of Environmental Sciences.

Member of Engineering Society of Detroit.

Member of SAE A6C Committee on Aircraft Hydraulics and various subcommittees and panels in connection with aircraft work.

During the past 5 years, I have been the author of 12 technical papers and 2 magazine articles dealing with Aircraft Hydraulics.

Licensed aircraft pilot since 1936. ■■■

RUSSELL T. LOWE
Vice-President – Membership

Bachelor of Science in Mechanical Engineering, Northeastern University; graduate courses in Mechanical Engineering and Business Administration, Northeastern University; Member of American Society of Mechanical Engineers, Institute of Environmental Engineers, American Management Association, Pi Tau Sigma, Tau Beta Pi, American Rocket Society, Society for Experimental Stress Analysis. Presently Chief Engineer of Barry Controls Incorporated, specialists in shock and vibration control. ■■■

HENRY F. SANDER
Executive Secretary

Education

Attended Illinois Institute of Technology - Electrical Engineering. Attended Northwestern University - Business Administration.

Professional Societies

Past member of the Society for Experimental Stress Analysis, the Instrument Society of America and the Science Section of the Environmental Equipment Institute. Past President of the Institute of Environmental Engineers. Presently the Executive Secretary of the Institute of Environmental Sciences. Past President of the Mt. Prospect Junior Chamber of Commerce.

Employment

Employed by Vapor Heating Corporation since 1948. Three years as an Environmental Test Engineer, five years as Chief Test Engineer. The past two years as Director of Standards and Quality Control. ■■■

system uses Freon 12 or Freon 22 to condense the Freon 13 in the lower stage, which is put through the heat exchangers in the chamber. Generally speaking, cascade systems have less connected horse power, but use a more expensive refrigerant (Freon 13) than the compound systems use. On large chambers each system should be considered but no hard and fast rule exists as to the better method for any individual application.

Heat exchangers are usually of two types, finned copper tubing, or "cold wall". Most chambers use the former with some manufacturers combining the two. Finned tube heat exchangers have the advantage of removal for easy repair, as opposed to the better heat removal capacity of the cold wall exchanger. Cold wall coils are usually made of deformed sheets of metal, bonded together so as to form refrigeration tubes. When such plates are used to form the actual wall of the working space, heat is removed very efficiently from the metal itself by conduction with a rather poor heat transfer from circulated air. Obviously, the best system would combine the best features of both.

HEATING SYSTEM

Electric power is almost universally used for obtaining temperatures above ambient with various types of convection heaters used in conjunction with a blower so as to minimize temperature gradients throughout the work space. Occasionally in special purpose chambers infra red or Quartz tubes are used to simulate radiated heat from a high speed aircraft or missile skin.

RELATIVE HUMIDITY SYSTEM

Some type of boiler is usually used to generate water vapor for relative humidity simulation. If tap water is used in the boiler considerable fouling will occur with resultant repairs and down time. Another system, and perhaps a better one, is the use of spray nozzles to put water onto heaters with the unvaporized water returned to a sump and recirculated until the desired humidity point is reached. This system is somewhat easier to control particularly in the temperatures close to ambient room temperature. A third system, the most reliable and most simple, consists of an immersion heater in a pool of water, but can be used only on a high (95%) relative humidity operation. Controlled dehumidification is usually accomplished by freezing out water vapor by means of a mechanical refrigeration system, and reheating the air to the proper temperature.

ALTITUDE SIMULATION SYSTEM

Altitude simulation is usually accomplished by means of vacuum pumps in the normal ranges up to 150,000 feet. However, in cases where altitudes in this range must be achieved quickly, such as a missile launch simulation, steam ejection systems have been used to good advantage. The steam ejection system also lends itself admirably where huge quantities of gases or products of combustion from a rocket engine, etc., must be disposed of while holding a simulated altitude. Recently, due to the need for simulation of "near space" conditions, oil and mercury diffusion pumps are being used for some special purpose chamber.

CONTROL SYSTEM

Temperature controllers vary from simple "off and on" non-indicating switches, up to indicating, recording, controlling and programming electronic strip and circular chart instruments. Today most chambers are equipped with indicating and recording controllers with either a "filled bulb" or thermocouple sensing element, depending upon desired accuracy and controlled temperature scale span. Most bulb type controllers, have an accuracy of about 1% of scale span, while thermocouple or resistance bulb controllers have accuracies as low as 1/5 of 1% of scale span. This essentially limits the bulb type instrument to a scale span of less than 350 °F, so as to maintain accuracies within the limits set by most of the MIL specs (plus or minus 3.6 °F). Therefore, if a large scale temperature performance is specified, a more expensive controller must be used to insure adequate temperature tolerances.

Relative humidity is controlled in most cases by wet and dry bulb instruments covering more or less the same categories as noted in the preceding paragraph.

The same accuracies obtain with the respective controllers but some further considerations must be reckoned with. Since the active wet bulb scale span is limited to 35 °F to 185 °F, this controller scale span is usually 0° to 200 °F with an accuracy of ±2 °F when using a filled bulb type instrument. When used with a dry bulb instrument having a scale span of –100° to +250° (Accuracy ±3.5 °F) one can see immediately that the MIL spec tolerances of ±5% on relative humidity is most certainly not too much. Let us take the case of 95% RH at 180 °F. This is defined by a dry bulb temperature of 180 °F and a wet bulb temperature of about 177.5 °F, with a tolerance of ±3.5 °F on the dry bulb temperature and a tolerance of ±2 °F on wet bulb temperature. We can have temperature variations of as wide a span as 183.5 °F DB maximum and 175.5 °F WB minimum, which is almost 83 °RH. If exactness of relative humidity control is an important consideration, we must use better controllers in this area. Perhaps the best control system is one using a thermocouple sensing element on dry bulb (accuracy ±.7 °F) and a differential wet bulb controller with a scale span of 75 °F (accuracy ±.15 °F). Since this wet bulb instrument will follow the dry bulb fluctuations correcting only the dry and wet bulb differential, extremely good control results.

Altitude simulation control may be simple and inexpensively accomplished manually with a "climb and dive valve" and Manometer or with "Bourbon tube" automatic controller with an accuracy of 1% of scale span of pressure range. A more sophisticated approach would utilize a transducer and balancing bridge circuit with an accuracy of as little as 500 feet at altitudes of 100,000 feet (.315" HG). In chambers simulating space conditions "cold cathode" instruments, McLeod gauges and other forms of "molecule" counters are being used.

No discussion of climatic testing equipment could omit some reference to the latest and perhaps most interesting development in this field. VIZ: the "space chamber". With the advent of "Sputniks", satellites, etc., normal climatic conditions have been forgotten with temperatures down to –300 °F and pressures below 1.3×10^{-3} MM of HG being requested in these special purpose chambers. With relatively few molecules of air remaining in the atmosphere, very little convection heat transfer is accomplished and if the test package is properly hung or supported there is essentially no conductive heat transfer. Under these conditions, practically all heat transfer must be accomplished by radiant heating or cooling methods. Since heat transfer rate is a function of the emissivity of the test package, the heating or cooling surface, and the temperature differential, extreme care must be used in the design of such systems. One manufacturer of climatic testing

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chambers reports excellent results using as many as fourteen separately controlled radiant heating and cooling "panels" in a single chamber.

As simulation of these altitudes demand diffusion pumps, etc. "cold trapping" is a "must" as a means of removing moisture from the air. Cold traps are in use with mechanical refrigeration systems as well as liquid CO_2 and LN_2 with all temperatures well below –80 °F.

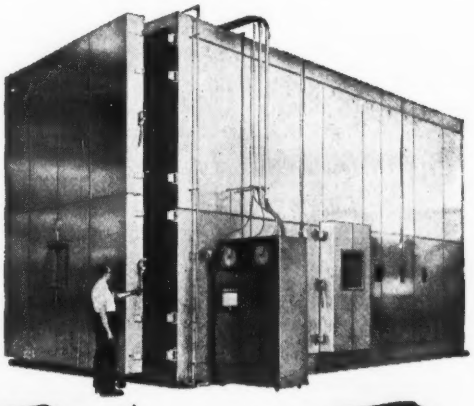
SUMMATION

In summation, the most important consideration is the end use of the test equipment. The best designed chamber is practically worthless if it is misapplied for no amount of flexibility of electrical connections, rigid climatic controls, etc. can make up for inadequate testing volume, or chamber space. Once the application requirements have been detailed, then the equipment user is in a position to establish specific performance specifications in this phase. There are normally two requirements that have to be balanced, namely: (a) Actual and anticipated test conditions. (b) Funding available. i.e., Immediate specification requirements may call out 100,000 feet and the user may anticipate 500,000 feet, but finds that he can only afford 250,000 feet altitude. Along the same line it is also necessary to make a decision whether one large combination chamber is more desirable than several small independent chambers. A single large chamber may provide superior test conditions but establish impossible scheduling situations, since a large combined chamber can only be used for one test at a time.

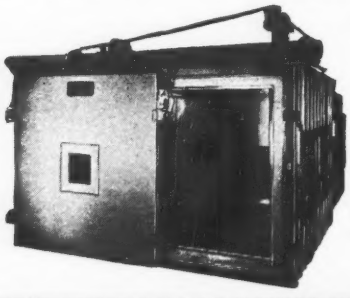
In probably no other field is the actual value of the final equipment so dependent upon initial decisions concerning end application requirements. Only through a broad understanding of available equipment, economic factors, and possible application conditions can the user be in a position to obtain the maximum chamber value per dollar he spends.

AR

The most advanced testing techniques are being built into American Research equipment right now!



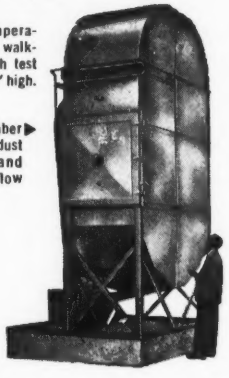
◀ Altitude, Temperature Humidity walk-in chamber 10' high x 8' wide x 12' deep interior with push-button door controls inside and out.



Altitude chambers in any size — Altitude 200,000' or higher; temperature +500°F and higher to −100°F and lower; Humidity 20% to 95%.

▲ Prefabricated Temperature and Humidity walk-in test facility with test space 12' x 25' x 15' high.

Sand and dust chamber ▶ includes automatic dust density control and stream-lined air-flow design.



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propriate, low noise, coaxial cable. To make the necessary measurements, the open end of the cable is connected to a cathode follower or voltage amplifier. The cathode follower or amplifier output is then measured and corrected for the gain characteristics of the cathode follower or amplifier.

In the system being described the cathode follower or voltage amplifier output is compared with an accurately known voltage supplied by a Calidyne Calivolter Model A23. The correct voltage is read from the Calivolter scale when the known and unknown voltages appear to be identical on the scale of a Hewlett-Packard 400D Voltmeter. To insure greater accuracy, the wave shape of the accelerometer output is continuously displayed on a Dumont 304A Oscilloscope and the wave's harmonic content is measured on a Hewlett-Packard Model 330B Distortion Analyzer. Also, the excitation frequency of the vibrator is continuously monitored with a Hewlett-Packard Model 522B Electronic Counter. Figure 8 shows a block diagram of the calibration system.

ACCELEROMETER CALIBRATION PROCEDURE

When accelerometers to be used for laboratory standards are calibrated, the following procedure is followed. With the accelerometer rigidly mounted on the upper surface of the aluminum cube containing the optical slit, the vibrator is excited at each of approximately twelve different frequencies ranging from 100 cps to 2000 cps as noted on the electronic counter. Only those frequencies at which the vibrator exhibits no lateral motion and which contain minimum harmonic content are chosen for calibration points. Five sets of displacement amplitude measurements are made at each frequency. Accompanying each displacement amplitude measurement is an accelerometer output voltage measurement made with the system diagrammed in Figure 8. The five displacement amplitude measurements as well as the five voltage measurements are averaged and these average values used in Equations 1 and 2 to compute the required accelerometer sensitivity. The accelerometer sensitivity computed in Equation 2 is then corrected for the gain characteristics of the cathode follower or voltage amplifier.

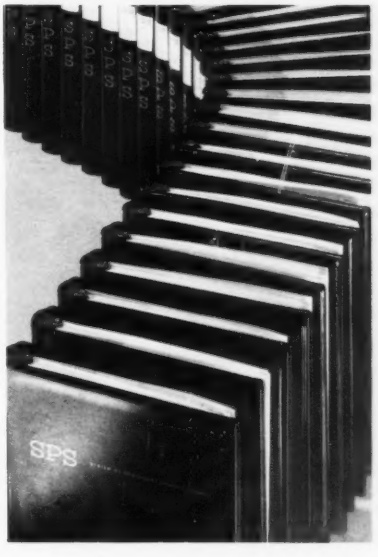
For routine accelerometer calibration where the test accelerometer is compared with the laboratory standard, the test accelerometer is mounted above the masonite plate with the standard accelerometer mounted below. Approximately 12 excitation frequencies at which minimum harmonic distortion and vibrator lateral motion occurs, are chosen for calibration points. Frequencies between 1100 and 1400 cps are normally excluded because of poor transmissibility characteristics of the masonite plate. Also, upon request, accelerometers are calibrated at various special frequencies.

To Be Concluded in OCTOBER ■■■

SPS

S - The MANUAL of test procedures
P - The ENCYCLOPEDIA of test information
S - The DICTIONARY of test interpretation

For Engineers, Technicians, Management



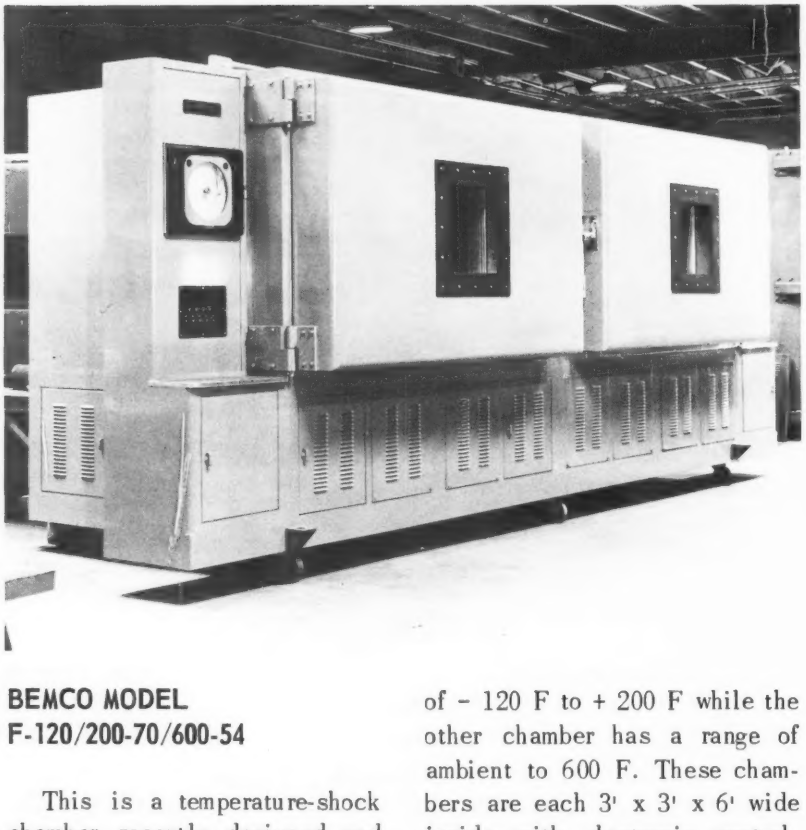
A LIBRARY OF TESTING INFORMATION

The System of Procedure Specifications provides test procedures covering requirements of Military Specifications such as MIL-E-5272, MIL-E-4970, MIL-STD-202 and collected procedures covering particular environmental testing such as vibration, shock, climatic, etc. Each SPS is handsomely bound and available on a subscription basis. The subscription carries one year's free service which will include revisions to keep pace with all military specifications.

The large number of major industries that are now subscribers to SPS are rapidly making SPS the industry recognized standard of test information.

Phone or write for a demonstration at your plant. System of Procedure Specifications, 11916 W. Washington Blvd., Los Angeles 66, California. Phone TExas 0-6821.

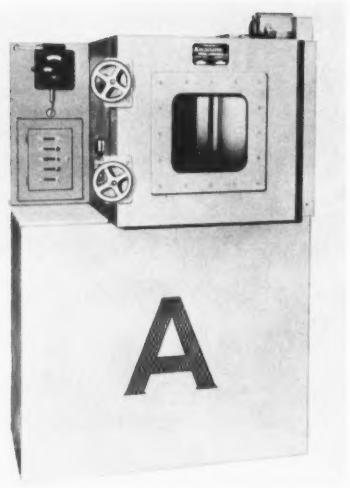
NEW products



BEMCO MODEL F-120/200-70/600-54

This is a temperature-shock chamber recently designed and manufactured for Redstone Arsenal by Bemco Inc., of North Hollywood.

This unit is two chambers on one frame for temperature shock work. One chamber has a range of - 120 F to + 200 F while the other chamber has a range of ambient to 600 F. These chambers are each 3' x 3' x 6' wide inside with electronic control, stainless steel interior and mild steel exterior construction. All equipment is contained in the one package including the refrigeration system. The unit is complete and ready for connection of utilities. ▪▪▪



NEW LOW-HIGH TEMPERATURE TEST CHAMBER FEATURES LIQUID CO2 REFRIGERATION

The Manufacturing Division of Associated Testing Laboratories, Inc., Caldwell, New Jersey, announces a new environmental test chamber for Low-High Temperature Testing in the range of –100 °F. to +1000 °F.

The utilization of liquid CO2 allows for extremely rapid pull-down if desired. Starting from ambient, a temperature of –100 °F. can be reached ***in less than 3 minutes.*** In addition, huge heat loads can be dissipated within the chamber --- at least 5000 BTU/hour at –100 °F.

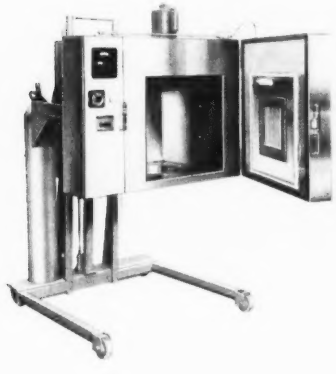
Working dimensions are 18" x 18" x 18". (Internal volume is 3.4 cubic feet).

An illustrated Bulletin C-13, and a four page article describing the Liquid CO2 System in detail, are available on request.

ASSOCIATED TESTING LABORATORIES, INC. MANUFACTURING DIVISION
Clinton Road
Caldwell, New Jersey. ▪▪▪

NEW HARRIS TEST CHAMBER FOR USE WITH VIBRATION EXCITERS

Harris Refrigeration Co., 308 River St., Cambridge 39, Mass. has developed a combination high and low temperature environmental test chamber designed for use with both horizontal and vertical vibration exciters.



Model 8LE-CO2 shown is 8 cu. ft., refrigerated by liquid CO2, controlled by a temperature indicating thermostat with a range of –125 °F. to +450 °F. The cabinet is heavily insulated with a combination of Kaylo high temperature insulation and glass wool.

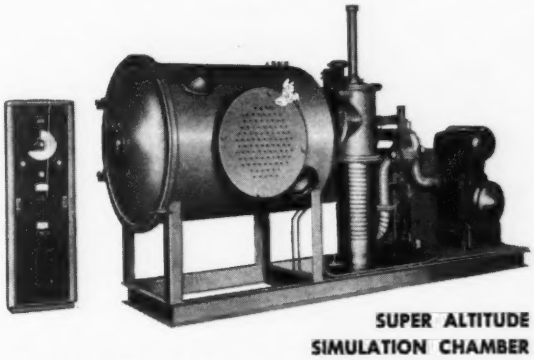
Other specifications: Free working space – 24" x 24" x 24". Outside dimensions – 46" x 36" x 36" high including motor. 14" entrance port in bottom of chamber for the exciter head. Two 2" entrance holes through chamber wall. Chamber mounted on 500 lb. capacity hydraulic lift positioning to use with either vertical or horizontal exciter. One year warranty against defective material or workmanship. ■■■

everyone talks about

"RELIABILITY"...

MURPHY & MILLER BUILDS IT!

Long before "reliability" became the magic word in describing every conceivable type of equipment, Murphy & Miller was building environmental test equipment that delivered reliability in terms that could be measured: CONTINUOUSLY ACCURATE PERFORMANCE UNDER THE MOST RIGOROUS OPERATING CONDITIONS. (We will always build reliability into everything that bears our name.)

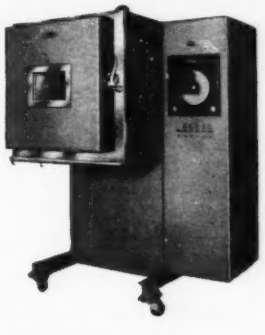


SUPER ALTITUDE SIMULATION CHAMBER

- Sea Level to 350,000 ft. (760 MM Hg to ½ Micron)

COMBINED TEMPERATURE and VIBRATION SIMULATION TEST CHAMBER

- Sizes 1 to 64 cubic feet
- Temperature Range: —120°F. to +500°F
- ALL STAINLESS STEEL TEST SPACE
- Optional Recording, Controlling, and Programming Equipment Available
- Self Elevating Chamber Available (Optional)



COLD TEST CHAMBER

- Temperatures to —200°F
- Stainless Steel Test Space
- Forced Air Circulation
- Heating cycles available to 300°F
- Test space capacities start at 1 cu. ft.

For the *best* in environmental test equipment, check Murphy & Miller first. Write for illustrated circular.

murphy & miller, inc.
620 West Taylor Street • Chicago 7, Illinois
Engineering Representatives In All Principal Cities
MEMBER OF ENVIRONMENTAL EQUIPMENT INSTITUTE

continued from page 23

MANUSCRIPT (With figures) .....January 6, 1960

REIMBURSEMENT

The IES cannot undertake to reimburse authors for expenses incurred in the preparation or presentation of their papers. However, authors whose papers are accepted for publication will be given complimentary registration for the entire three-day meeting, a copy of the Proceedings and five copies of their own paper. These complimentary arrangements will be made for only one person for each paper.

SUMMARY

The IES, in recognition of its responsibility to disseminate essential advanced information in the environmental sciences, advocates adherence to the foregoing policies, which action it believes will culminate in a superior technical meeting. However, this objective cannot be attained without the understanding and cooperation of all the meeting participants. With the willingness of the contributors to cooperate, the 1960 IES National Meeting can provide the long-awaited leap forward in the race to outer space.

Doc. #IES - 60 N M 3 -- Format for the Technical Sessions

References: 1. DOC # IES-60NM 1 Meeting Outline

2. DOC # IES-60NM 2a Administrative Policies

PURPOSE

The purpose of this document is to set down a preliminary format for the technical sessions of the national meeting, so that authors and other participants may plan their oral presentations to be compatible with the times allotted.

PLAN

Each paper in the technical sessions will be allotted a total time of 40 minutes for discussion. This will comprise a 20-minute presentation by the author, two 5-minute commentaries (prepared), and a 10-minute general discussion by the audience.

There will be three or four papers presented at each session. It is contemplated that the morning and afternoon sessions will be scheduled approximately as follows:

Morning Session

8:50 - 9:00 AM	Opening Remarks, Chairman
9:00 - 9:40 AM	First Paper
9:40 - 10:20 AM	Second Paper
10:20 - 10:40 AM	Break
10:40 - 11:20 AM	Third Paper
11:20 - 12:00 Noon	Fourth Paper

12:10 - 1:40 LUNCHEON

Afternoon Session

1:50 - 2:00 PM	Opening Remarks, Chairman
2:00 - 2:40 PM	First Paper
2:40 - 3:20 PM	Second Paper
3:20 - 3:40 PM	Break
3:40 - 4:20 PM	Third Paper
4:20 - 5:00 PM	Fourth Paper

OPERATIONAL TESTING under all ENVIRONMENTS

Use our facilities to evaluate product operation under all environmental conditions. Get automatic alternating cycles of contrasting conditions...remote control of product operation by mechanical, electrical or hydraulic means... and a wide range of supply voltages and frequencies. Simulate high-low temperatures, humidity, altitude, explosion, immersion, salt spray, sand and dust, rain, fungus, vibration, shock, acceleration, etc. Test to military, government and commercial specifications.

Complete facilities in the fields of chemistry; metals chemistry; metallurgy; physical testing of materials; engineering analysis of mechanical, electromechanical and electronic devices; site inspection; package testing; psychometrics and certification services for product quality control.

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COMING EVENTS

- **August 24–27:** Fourth Symposium on Ballistic Missile and Space Technology, Los Angeles, Calif. Sponsors: USAF's Ballistic Missile Division; Space Technology Laboratories, Inc.

- **September 1–2:** Conference on physical chemistry in aerodynamic and space flight, University of Pennsylvania, Philadelphia, Pa. Sponsors: Air Force Office of Scientific Research and General Electric Co.'s Missile and Space Vehicle Dept.

- **September 14–16:** 14th Midwest Quality Control Conference, American Society for Quality Control, Sheraton Hotel, French Lick. Ind.

- **September 16–17:** Western Regional Meeting on Frontiers on Science and Engineering, Institute of the Aeronautical Sciences, Los Angeles, Calif.

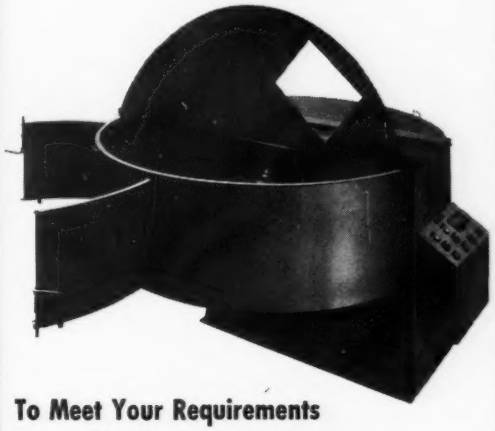
- **September 20–25:** 14th Annual Conference and Exhibit, Instrument Society of America, Chicago, Amphitheater, Chicago, Ill.

- **September 28–30:** 1959 National Symposium on Telemetering, Civic Auditorium and Whitcomb Hotel, San Francisco, Calif. Sponsor: Institute of Radio Engineers' Professional Group on Space Electronics and Telemetry.

- **October 6–9:** International Symposium on High Temperature Technology, Asilomar Conference Grounds, Monterey Peninsula, Calif. Sponsor: Stanford Research Institute.

- **October 12–14:** 15th National Electronics Conference, Hotel Sherman, Chicago, Ill.

ELECTRONIC SPEED CONTROL EXCLUSIVELY ON RUCKER SMALL CENTRIFUGES



To Meet Your Requirements For Acceleration Testing Under MIL-E-5272 A Procedures I and II

The new electronic speed control circuit—an exclusive feature on Rucker Series I Centrifuges, provides:

- ✓ DIGITAL CONTROL SETTING: Only one setting required to reach any desired speed.
- ✓ PROGRAMMED SEQUENCE OR REMOTE OPERATION
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OTHER RUCKER FEATURES:

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- ✓ WAVE GUIDES FOR ALL APPLICATIONS (Optional)
- ✓ CLOSED CIRCUIT TV (Optional)
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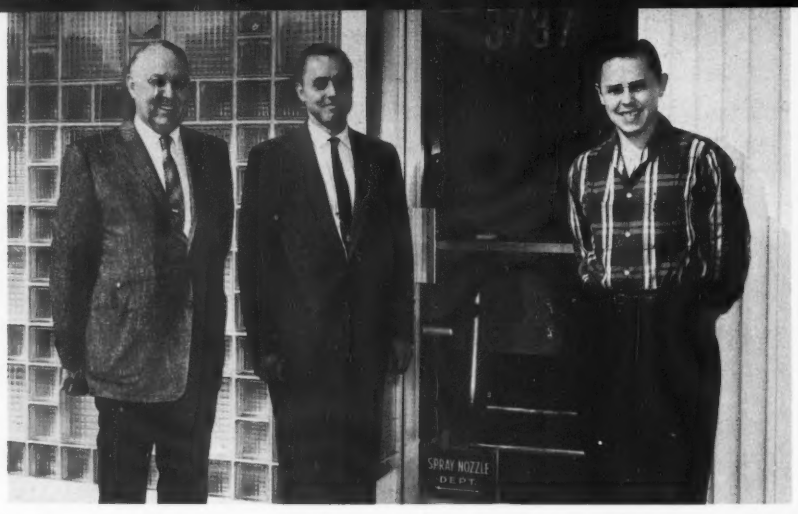
Rucker Series 10 and 20 Centrifuges also available with capacities in excess of 450,000 G pounds and diameters to 70 feet.

The RUCKER Company
Since 1941
4700 SAN PABLO AVENUE • OAKLAND 8, CALIFORNIA
ATTENTION: *Openings now for Qualified Engineers—for Design and Sales*

Names and Faces



D. J. Missimer, Dale J. Missimer, Jr., and George L. Missimer are shown in front of their new plant located at 3737 San Fernando Road, Glendale, California. According to Dale Missimer, Jr., Vice President of the company, the new plant houses the manufacturing of Missimer's environmental test chambers, technical refrigeration equipment, and sales distribution office of Spraying Systems, Inc. ■■■

MB NAME CHANGE

NEW HAVEN, Conn. -- Expansion plans for MB Manufacturing Company, including a name change to MB Electronics, have been announced by George W. Miller (center), president of the MB parent organization, Textron Electronics, Inc. Discussing plans are (left) Herman E. Goodman, vice president and director of public relations, Textron Inc., New York, and (right) George H. Mettler, president, MB Electronics, New Haven.

MB produces vibration test equipment and associated electronics apparatus and systems. A major reason behind the name change, according to Mr. Mettler, is the increasing importance of electronics in the company's growth picture. ■■■

ASSISTANT CHIEF ENGINEER APPOINTED BY PTF

NEW HAVEN, Conn. -- The appointment of Gerret B. Conover as assistant chief engineer, Propulsion Test Facilities, Inc., has been announced by Norman G. Froomkin, vice president and general manager. PTF is an affiliate of MB Electronics, a Division of Textron Electronics, Inc.

Mr. Conover formerly was assistant chief engineer, Propulsion Test Equipment Division, Penn-Texas Corporation. Prior to this he was project engineer, test equipment design, Wright Aeronautical Division, Curtiss-Wright Corporation. ■■■

ENGINEERED TESTING

ENVIRONMENTAL TESTING

Test equipment for the following environmental conditions is available in the laboratory as follows:

VIBRATION:	600# force; 2000 cps
ACCELERATION:	50# @ 50 g's
SHOCK:	Per Spec. 7201
TEMPERATURE: & HUMIDITY:	200°F 100% R. H.
TEMPERATURE: & ALTITUDE:	−100°F to +200°F 100,000 ft.
HIGH TEMP.:	To 1,000°F
RAIN:	4" per hour
SUNSHINE:	Per MIL-E-5272A
EXPLOSION:	Per MIL-E-5272A
FUNGUS:	Per MIL-E-5272A
SALT SPRAY:	Per MIL-E-5272A
SAND & DUST	Per MIL-E-5272A

All environmental equipment is suitably instrumented with recording, indicating and controlling devices and fully complies with the requirements of the Military Specification MIL-E-5272A.

FUNCTIONAL TESTING

Supplementing the normal services of an environmental test facility, Parameters, Inc. is also capable of functionally testing all components. Parameters, Inc. maintains a complete hydraulic, electronic and mechanical test facility to provide a 'one-stop' testing organization.

HYDRAULIC PUMPING UNITS

Flows to 100 gpm
Pressure to 5,000 psi dynamic
30,000 psi static
Fluids JP-4, JP-5, Varsol MIL-0-5606, OS45 MIL- -7808

PRIME MOVERS

Power from 1/20 to 160 HP; controlled variable speeds.

HYDRAULIC IMPULSE

Per MIL-5512-A

ELECTRICAL POWER

400 amp, 3 phase, 60 cps; 28 volts d-c; 400 cps.

INSTRUMENTATION – General electronic test equipment, including recorders, oscilloscopes, meters and oscillators. Transducers including flowmeters, pressure transducers, thermocouples and potentiometers.

SPECIAL EQUIPMENT – Specialized equipment for testing electro-hydraulic closed loop systems includes variable gain servo-amplifier, sine wave generator, phasemeter, servo valve and rotary and rectilinear potentiometers.

FOR MORE INFORMATION ABOUT THE TESTING, ENGINEERING, DESIGN OR DEVELOPMENT FUNCTIONS OF PARAMETERS, INC., WRITE TO:

PARAMETERS, inc.

195 HERRICKS ROAD
NEW HYDE PARK
NEW YORK
Pioneer 7-8484

I. E. S. News Letter

The I. E. S. Newsletter will inform the members of activities carried on in the many local chapters. Leon Carver, Vice President Local Chapters, will report the various activities to the Journal. News of present chapter activities and inquiries from groups contemplating forming chapters should be forwarded to the Institute of Environmental Sciences, Box 191, Mt. Prospect, Illinois. Attention Leon Carver.

For the present, we wish to inform the members of the following chapters and officers.

LOS ANGELES CHAPTER

Chairman
Jerome Bakalish
Firestone Guided Missile Div.
Los Angeles, Calif.

Vice Chairman
Frank J. Reinsch
Gilfillan Bros., Inc.
Los Angeles, Calif.

Secretary
Orville G. Baer
Gilfillan Bros., Inc.
Los Angeles, Calif.

The Northern California Chapter has applied for recognition. The local steering committee that organized this group was:

Chairman
R. C. Geiger
Lockheed Missiles & Space Div.

Vice Chairman
J. A. Biberdorf
Philco Corporation

Secretary
R. E. Lewis
Lockheed Missiles & Space Div.

Organization of additional chapters is in progress in the follow-areas:

Birmingham, Alabama

Tampa - St. Petersburg, Florida

San Diego, California

St. Louis, Missouri

BOSTON AREA CHAPTER

President or Chairman
Robert J. Graeff
Equipment Sales Co., Inc.
Danvers, Massachusetts

Vice President
Marvin Tolf
Acton Laboratories
Acton, Massachusetts

Secretary
Alvie Jorgensen
Raytheon Mfg. Co.
Wayland, Massachusetts

NEW-YORK METROPOLITAN CHAPTER

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Item Lab Inc.
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Vice President
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Vice President
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Westinghouse Air Arm Division
Baltimore, Maryland

Secretary
Daniel Grady
General Electric Co.
Philadelphia, Pennsylvania

TECHNICAL INFORMATION

COMPLEX VIBRATION TRAINING SEMINAR ANNOUNCED

MB Manufacturing Company will hold a series of training seminars on complex vibration testing starting in June, 1959, it was announced by George Mettler, president.

Each seminar will last two weeks. It will consist of lectures at Yale University under the direction of Dr. Theron Usher of the University's Electrical Engineering department and demonstrations and practice with equipment of MB facilities. Seminars will be held monthly and limited to ten men.

The course will include:

1. Basic random noise theory
2. Principles of operations of exciters
3. Equalization procedures and techniques
4. Power amplifier requirements and basic design
5. Limiters and protective devices
6. Measurement, display and recording techniques
7. Basic sinusoidal testing techniques
8. Practice in operations of typical systems

For further information write to Wayne Tustin, Preliminary Design Engineer, MB Manufacturing Company, 781 Whalley Avenue, New Haven, Conn. ▪▪▪

PG EWS SYMPOSIUM TO STRESS TECHNIQUES

The Third National Symposium of the IRE Professional Group on Engineering Writing and Speech is being sponsored jointly by the Boston and Los Angeles Sections and will run concurrently in both cities on September 17th and 18th.

The West Coast meeting will be held at the Ambassador Hotel in Los Angeles and has as its theme, "Better Engineering Writing & Speech: A National Necessity." Dr. L. C. Van Atta, Fellow of the IRE and Head, Technical Information and Education, Hughes Aircraft Co. will give the keynote address.

The primary purpose of the West Coast meeting is to provide the working engineer with practical information that will help him communicate more effectively. Sessions have been carefully planned to provide something of value to all engineers. Those who attend will find that two of the four sessions are on "Techniques for Better Engineering Writing & Speech"; Dr. Nathan I. Hall, Vice President of Engineering, Hughes Aircraft Co. will be chairman of one of these sessions and James Harrison, Staff Director, Joint Congressional Committee on Printing will be chairman of the other. The two remaining sessions are "Defense Demands Better Engineering Writing & Speech" with Admiral C. V. Horne, USN (Ret.), Vice President and General Manager, Convair-Pomona as chairman; and "Education for Better Engineering Writing & Speech" with Dean L. M. K. Boelter, College of Engineering, UCLA, as chairman. ▪▪▪

ENVIRONMENTAL TEST EQUIPMENT DATA BOOK

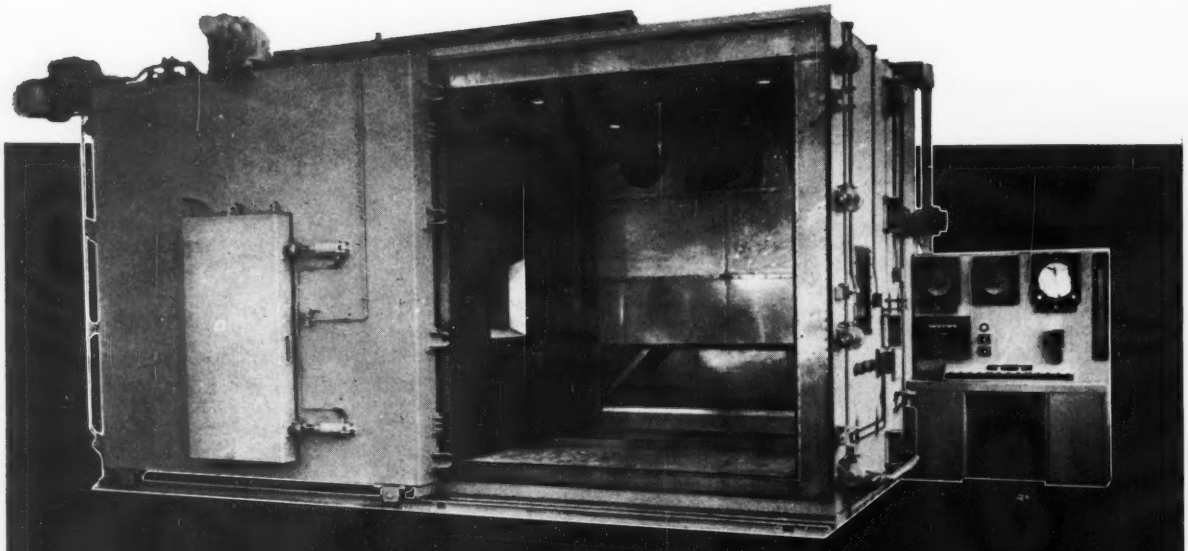
Dale J. Missimer, Jr. announces that a data book outlining the various aspects of chamber construction is available upon request.

The data book covers heating systems, humidifying and dehumidifying systems, altitude systems and other points of chamber construction such as windows, doors, accessories, insulation, etc. Detailed descriptions are given of the major areas previously mentioned.

The data book contains numerous illustrations, charts and graphs. Also included is an ex-

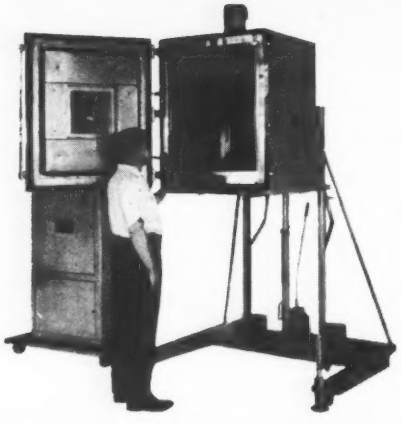
Continued on page 40

For big walk-ins, small portables, or sizes in between, check with CONRAD Inc.



1000 CU. FT. This temperature-altitude-humidity chambers is the latest of several Conrad chambers installed at one of the nation's largest missile component plants. Temperature range, —100° F. to +350° F.; altitude, 0 to 100,000 ft.; humidity automatically programmed from 20% to 95%. Capable of dissipating 10,000 watts at —100°F.

Other features include rain simulation for testing in accordance with Mil. Spec. 5272 — push-button control for stopping door at any point within a fraction of an inch — push-button alarm system — and inter-com.



8 CU. FT. Adjustable temperature-vibration test chamber. Refrigeration effect is accomplished with liquid CO_2. High temperature limit, +1000°F. Entire unit, including control panel, full mobile.

CALL OR WRITE FOR COMPLETE INFORMATION

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RYan 1-0181

COLO.: DENVER
Vernon Parrish
1810 S. St. Paul
SKyline 6-6884

CONN.: KENT
R. M. Alden
Box 278
WAlker 7-3319

FLA.: CLEARWATER
W. Ben Wimberley Co.
532 S. Ft. Harrison Ave.
3-7072

FLA. ORLANDO
W. Ben Wimberley Co.
GArden 5-3083

GA.: ATLANTA
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Lew Wright
3230 Peachtree Rd., N.E.
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ILL.: CHICAGO
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5329 W. Belmont Ave.
AVenue 3-6111

MO.: ST. LOUIS
Warren Hull
828 Thornberry
TAylor 2-2241

N.Y.: NEW YORK CITY
Ralph M. Alden
21 Park Pl.
BArclay 7-7583

OHIO: TOLEDO
M. Denver Armstrong
P.O. Box 294

TEXAS: DALLAS
W. N. Wright
5738 N. Central Expressway
TAylor 4-2571

TEXAS: HOUSTON
N. Gene Simpson
1803 Calumet St.
JAckson 3-5651

UTAH: SALT LAKE CITY
Vernon Parrish
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SKyline 6-6884

CANADA: TORONTO, ONT.
Donald E. Beechey
290 Lawrence Ave., W.
RUssell 7-3861

FREE ATMOSPHERE AND TEMPERATURES CHART. Convenient pocket-size table of pressures from 0 to 1,800,000 ft. Write direct or ask your Conrad representative.

NEW PORTABLE TEST CHAMBER

Fits into 19" Relay Rack

CONRAD *Inc.*

TEMP-RAC 19

TEMP-RAC 19 is a 1½ cu. ft. chamber with a choice of precision-controlled temperature ranges — —100°F. to +350°F., or —70°F. to +300°F. — for testing components and sub-assemblies in accordance with military specifications. It's *convenient* — fits into standard 19" relay rack. It's *economical* — you can install several in your plant for new versatility in testing small components. And it's *quality* — engineered and built by Conrad.

★ *Fits your Standard 19" Relay Rack, Or Can Be Supplied Ready-Installed in Rack.*

★ *Temperature Ranges, —70°F. to +300°F. and —100°F. to +350°F.*

★ *Temperature Stability to Within + or —2°F.*

★ *Portable*

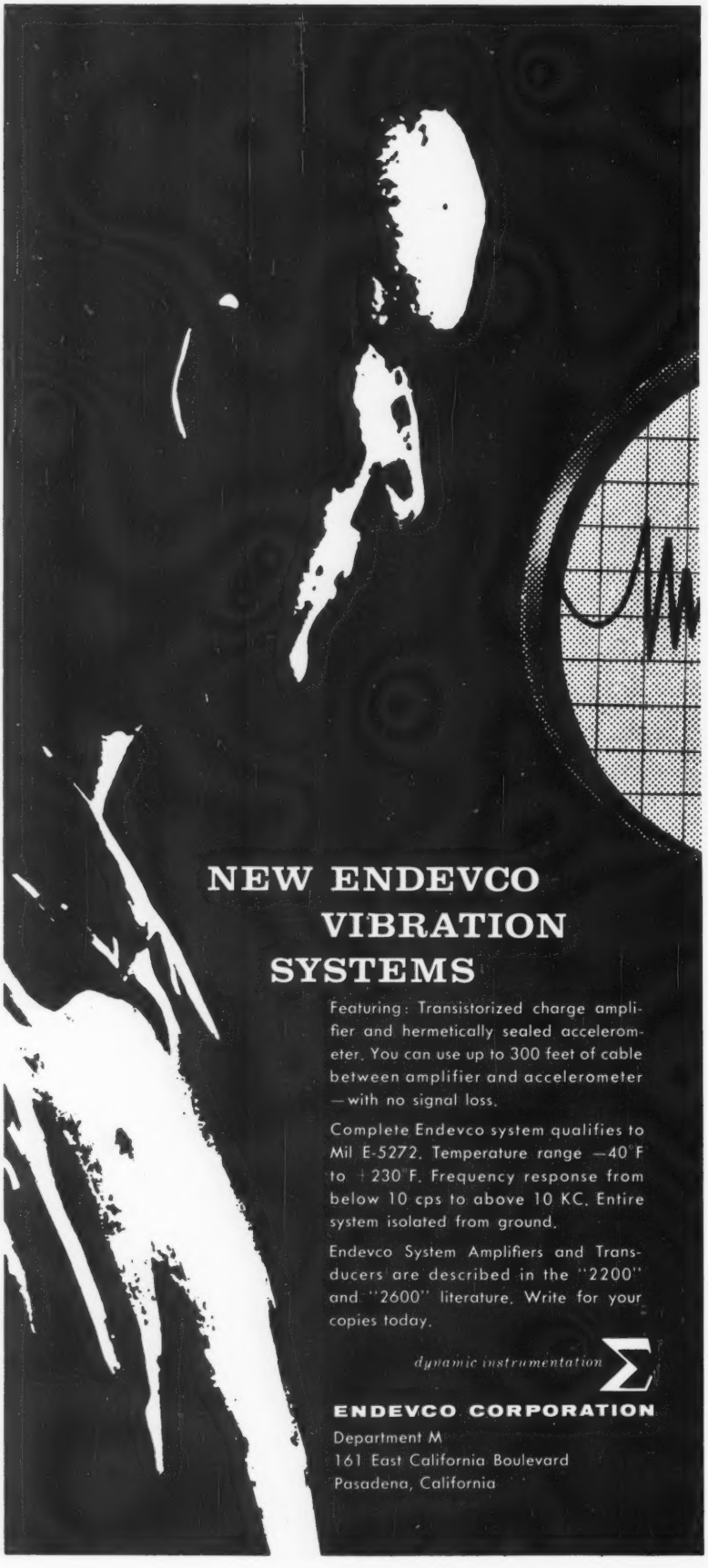
★ *Air Cooled*

★ *Operates From Single Phase Power*

★ *Occupies Only 4. Sq. Ft. Floor Space*

★ *Saves Time, Work, Operational Costs*

For More Information, Write Conrad or Your Nearest Conrad Representative


NEW ENDEVCO
VIBRATION
SYSTEMS
Featuring: Transistorized charge amplifier and hermetically sealed accelerometer. You can use up to 300 feet of cable between amplifier and accelerometer —with no signal loss.
Complete Endevco system qualifies to Mil E-5272. Temperature range —40°F to +230°F. Frequency response from below 10 cps to above 10 KC. Entire system isolated from ground.
Endevco System Amplifiers and Transducers are described in the "2200" and "2600" literature. Write for your copies today.
dynamic instrumentation
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Membership in IES

Several classes of membership will be provided in the Institute of Environmental Sciences which parallel those of other societies, namely: Fellow, Honorary Fellow, Member, Associate Member, Student, Government Member, and Company Member. Requirements for the individual classes of membership are presently being established and will be available upon application for membership. All present members of SEE and IEE will automatically be eligible for the member classification without further qualification. Fellows and Members are eligible to vote and hold office. Associate Members may vote but cannot hold office. Student, Government and Honorary Members do not vote or hold office.

APPLICATIONS

For further information regarding membership write to The Journal of Environmental Engineering, Box 191, Mt. Prospect, Illinois. Attention: Russell Lowe, Vice President, Membership. ■■■

Continued from page 37

tensive bibliography covering publications pertaining to chamber construction.

Price: $1.00

Write: Dale J. Missimer, Jr.
Missimers, Inc.
3737 San Fernando Road
Glendale 4, California ■■■

LOW COST CENTRIFUGE

for large-quantity acceleration test programs

Genisco Model A903 features simplified operating procedures; rugged construction... for fast, accurate testing to MIL-E-5272A, Procedure II

Although the A903 is a simple, low cost centrifuge, it has many features found in more sophisticated machines, *plus* unique features which particularly suit it for production-line testing and evaluation programs.

SIMPLE OPERATION—Except for an on-off switch, controls are limited to a single handwheel which controls table speed. Chance of human error is reduced to a minimum. Test personnel can learn its operation in minutes.

SPEEDS TESTING—24" diameter mounting-table will accommodate several test objects. Arranged symmetrically, they can be subjected to acceleration forces simultaneously.

RUGGEDLY-BUILT—Virtually immune to operational abuse. Will operate for long periods without maintenance as demanded for production test programs.

0.5% ACCURACY—Constancy of rotation of the mounting-table is within 0.5%, including wow and drift. Table rotation speed can be measured electronically within ±1 count.

BRIEF SPECIFICATIONS

G-Range: 1 to 1,000 g's in five standard ranges, infinitely variable

G-Pound Capacity: 2,500 g pounds, maximum

Constancy of Rotation:

- **Wow:** 0.5%, maximum
- **Drift:** 0.2% of rate per minute, maximum

Speed Indication Accuracy:

- **Tachometer:** ±1¼%
- **Magnetic Pickoffs:** 60 tooth pickoff gear standard; 600 tooth gear optional. Pulses are fed to a front panel coaxial receptacle for use with any standard electronic counter.

Vibration Isolation: 0.1 g in any plane, at any speed

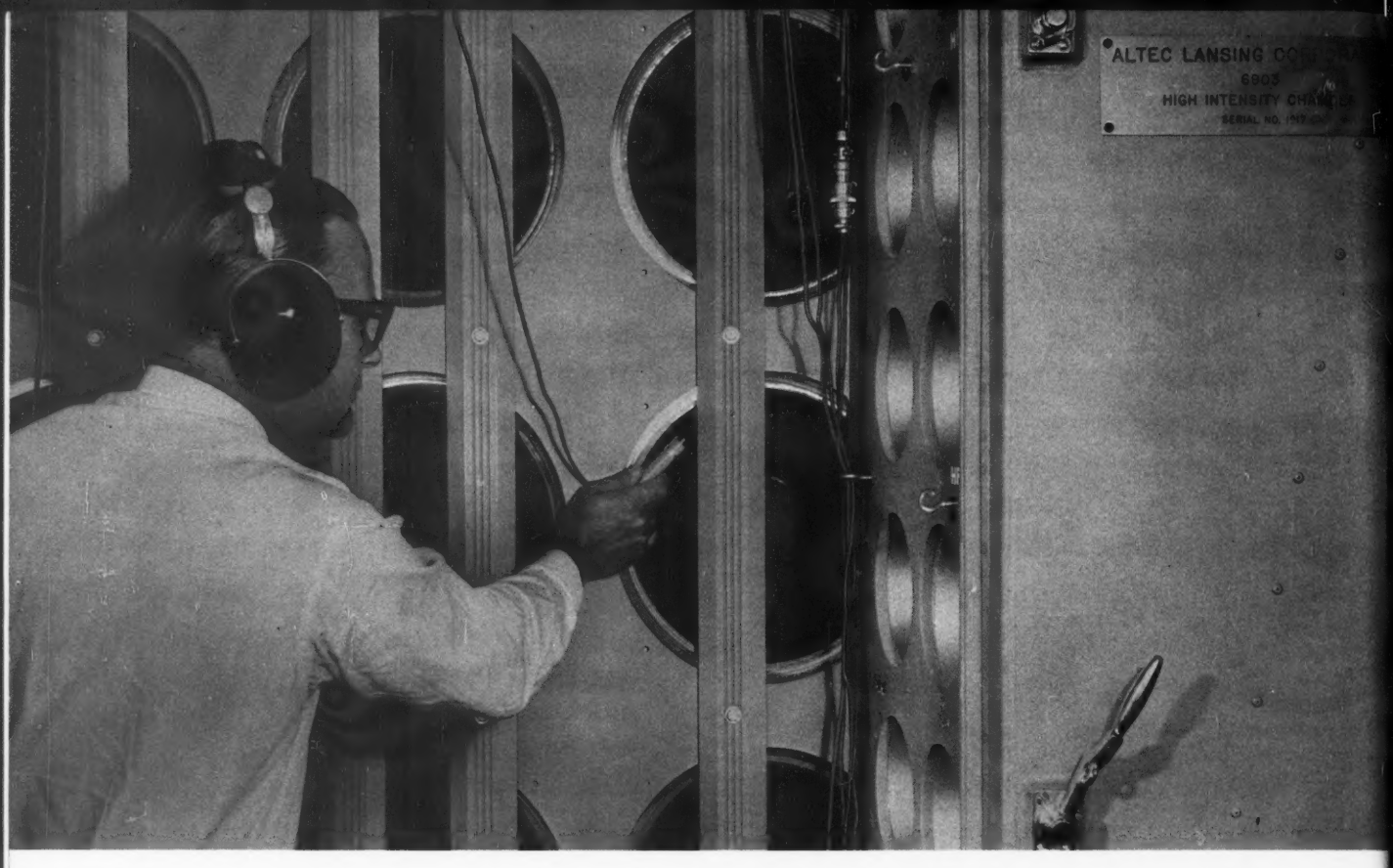
Test-Object Dimensions: 8" high (24" diameter circular platform)

Slip Rings: 8 standard, 10 amp. maximum

Write for complete technical information and prices.

Genisco INCORPORATED

2233 FEDERAL AVENUE • LOS ANGELES 64 • CALIFORNIA



High Intensity Sound

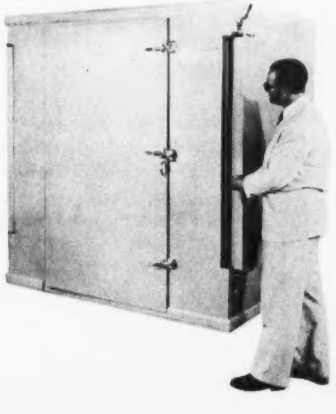
a destructive, powerful force . . . a useful, versatile tool!

The destructive forces of high intensity sound – both in vibration and heat produced – are now better understood and better controlled through the use of testing chambers such as this latest Ling-Altec Reverberation Chamber.

Here, an Engineer adjusts one of the monitoring microphones in a chamber that can produce over 150 db of white noise – enough to equal the noise spectrum of the most powerful modern jet engines.

Even greater forces can be produced in Ling-Altec Plane Wave Tubes with air modulated devices which concentrate the power of high intensity sound many times.

These developments are a part of the continuing leadership of the Ling-Altec combination – high power electronics and high intensity sound!



LING

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